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Roosting of bronzed grackles and avian associates at Ames, Iowa

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ROOSTING OF BRONZED GRACKLES AND AVIAN ASSOCIATES AT AMES, IOWA

by

John C. W. Bliese

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INTRODUCTION

When tens of thousands of bronzed grackles, Quiscalus quiscula versicolor (Vieillot), and associated birds descend upon a residential area each summer and fall evening to roost, some problems are presented. The resulting noise, offending odors, unsightly walks, bespeckled parked automobiles, and lowered property values create understandable adverse attitudes on the part of most of the affected citizens. If we were dealing with only a local phenomenon the consequences would not be so grave. It is not an isolated occurrence, however, for it is repeated over and over in towns and cities of the Midwest, and apparently also in similar locations in a belt extending to the Atlantic Ocean. Surprising as it may seem, little has been done in attempts at systematic control of such roosts.

The most numerous of the birds roosting at Ames, Iowa, have been the bronzed grackles. Regularly associated with the grackles have been starlings, Sturnus vulgaris vulgaris Linnaeus; eastern cowbirds, Molothrus ater ater (Boddaert); and eastern robins, Turdus migratorius migratorius Linnaeus. At times purple martins, Progne subis subis (Linnaeus); giant red-wings, Agelaius phoeniceus arctolegus Oberholser; and English sparrows, Passer domesticus domesticus (Linnaeus) were present also. These same species have caused roosting problems in other communities in the regions mentioned.

Disturbing though such gregarious birds may be to some people,

students of bird life have found that grackle roosts and roosting flights were interesting spectacles, and consequently a number of writers have commented about them in the literature. Nevertheless, only a few bird students have attempted any serious studies of grackle habits, and little or nothing has been published concerning the preferences of the birds in selecting roosting sites, or concerning the factors involved in roosting flights. Detailed knowledge of either possibly could lead to control measures. Even casual preliminary work at Ames revealed that certain trees were used repeatedly as roosting sites and others avoided, or at least not used; and that flight lines were definite and localized, yet somewhat variable. The present study was attempted, therefore, to ascertain whether or not readily measurable factors determined the roosting behavior of the birds. While there was no desire on the part of the writer to study the problem of control of such roosts, it was hoped that some suggestions for mitigating the trouble might result.

REVIEW OF LITERATURE

Preliminary Remarks

In reading the literature concerning grackles the writer frequently had to judge from the context, or from the locality described, whether the author was writing about the bronzed grackle or about the purple grackle, Quiscalus quiscula stonei Chapman. Some writers have not made any distinction between the two subspecies or may even have confused them. Since the roosting habits of the two birds are apparently quite similar, the difficulty is probably of a minor nature, and no particular emphasis on subspecific designations is made in this section.

Grackles are commonly called "blackbirds" in some parts of the country, and since a number of writers have used that term, it is also used in this section. Wherever used it means "grackles", unless the context clearly indicates a more general designation.

As the present study was made in summer and fall and concerned grackles primarily, emphasis is given to literature describing the roosting of grackles during those seasons, either alone or with other species. Little is said about starlings, cowbirds, robins, or other species roosting by themselves, and winter roosting receives scant attention. Within any one section the literature is reviewed more or less in chronological order.

Composition of Roosts

Roosts used primarily or entirely by grackles

Grackles have been found to roost in a variety of locations, but descriptions given by writers have frequently been very general. According to Wilson (1876) they roosted in nearby cedars and pines, and Maynard (1881) noted that these birds usually selected a thick swamp, apparently after nesting, but he did not describe such a roost in any detail. Palmer, T. C. (1887) saw many thousands of blackbirds, robins and English sparrows in the large maples and lindens of the court house square in Media, Pennsylvania. Other roosting sites for grackles in Pennsylvania were found to be cedars, pines, thick woods, and dense thickets by Warren (1890). Farther west, Bendire (1895) mentions thousands of grackles roosting with red-wings in willows at Peoria, Illinois, during the spring.

A three-year study was made of the summer grackle roost on the college campus at Oberlin, Ohio, by Jones (1897) who observed the birds from the time of their arrival in spring until their departure in the fall. On the campus, which was essentially level, were elms, oaks, and conifers, as well as a grove of maples. Jones considered the grove of maples to be the roost, but noted that neighboring trees were also used by the birds when they became numerous. Prior to the study the birds roosted in an orchard, then in trees near Plum Creek, and still later in a residential area in Oberlin, but the exact species of trees mentioned were not given. Over 5,600 grackles, about 350 cowbirds, and a few robins were present at the height of the roosting season.

A grackle roost in Germantown, a part of Philadelphia, Pennsylvania, was described by Emlen, A. C. (1902). It included both nesting and roosting, and consisted of patches of beech and maple on the southwest slope of a 50-acre tract. Although only 12 pairs of grackles nested here, hundreds were present for roosting; and robins, cowbirds, red-wings, and English sparrows joined the roost during August and September. Some roosting occurred here intermittently even in winter, and during one winter about 50 grackles were present nearly every night.

After a storm destroyed most of the roost at Media, Pennsylvania, the birds frequented woodland west of the community (Omensetter, 1905). Tens of thousands of grackles used an area which was covered with second growth chestnut trees. Nearness to a past nesting ground, which was situated in the conifers in Media cemetery, was thought to have been a factor in choosing this site. Omensetter thought that as such conifers became scarcer, and the blackbirds reared there became more numerous, lack of lodgings may have brought about a dispersion of the birds and the abandonment of that habitat. Another shift occurred in 1905 when the Pennsylvania legislature took the grackles off the protected list and put them on the game list. The birds then tended to use evergreen trees and taller deciduous trees in the west part of Media, presumably in response to intensified molestation.

Peck (1905) told of another roost in Philadelphia, the Overbrook roost, which was on a 19-acre estate and consisted of deciduous trees mixed with a number of conifers, all trees of good size. The land was rolling and there was an artificial lake of one acre on the estate. This site was used throughout the year, with 400 to 500 grackles present

in January and up to 75,000 in September and October. No red-wings were ever noted, but 1,000 or more robins joined the roost during the summer, and four screech owls lived there continuously.

A roost in a neglected nursery near the Concordville station, in Delaware County, Pennsylvania, was described by Palmer, S. C. (1906). It covered an area about 100 by 200 feet in dimensions, was situated on a high prominence which sloped away to the north and south, and consisted of a nearly uniform stand of chestnut and maple trees not over 20 feet tall. Palmer estimated that 3,000 grackles, 2,500 robins, and 2,000 cowbirds roosted here the latter part of August; and although he saw no redwings, he noted that one had been picked up dead several days before he made his observations. The birds had formerly roosted in some woods one-fourth mile away, but had left that place when it was trimmed and the underbrush cut out.

In a summary of the observations sent in by ten members of the Delaware Valley Ornithological Club, Potter (1912) listed a number of roosts, of which the Germantown roost has been mentioned. The Swarthmore, Pennsylvania, roost contained nesting grackles in the spring, and was composed of deciduous and coniferous trees of various sizes. There the grackles did not select only one site, but moved several times in and near the community. The largest number of birds roosted in the fall when about 5,000 grackles were present, together with some robins and cowbirds. Another roost composed of mixed growth, and used as a nesting area by grackles, was the one in Philadelphia at the Kirkbride Asylum where approximately 1,000 grackles roosted in the fall. The North Woodbury, New Jersey, roost was a one-acre tract of sweet-gum trees within a 40-acre scrub oak

woodland. As at the Kirkbride roost, red-wings, starlings, and cowbirds were present with the grackles, which numbered about 6,000 in September. These roosts, and the tall trees in and about the community of Audubon, New Jersey, seemed to be primarily summer and fall roosts, and eventually were deserted each fall. Potter concluded that any kind of growth, of any size, was satisfactory for roosting, and that most roosts began as nesting colonies.

Snow Hill, south of Haddonfield, New Jersey, had a roost for some time (Rhoads, 1913). The wooded portion, about four acres in extent, consisted of bushy pines on the higher portions; oaks, gums and chestnut trees farther down; and oaks, red maples and black gums in the swampy area near the bottom. The trees were surrounded by cleared land on all sides, and ranged in size from 12 to 18 feet high at the top of the knoll to 40 to 50 feet high in the swamp. The blackbirds, estimated at 3,000 to 4,000 during the latter part of August, roosted in about two acres of the tallest trees. Associated species included robins, starlings, doves, migratory warblers, finches, thrushes, and woodpeckers, but the doves and starlings roosted in the pines on the knoll away from the blackbirds.

Burns (1926) described a late fall roost in Berwyn, Pennsylvania, where about 500 grackles and starlings began roosting in the author's cherry, locust, and apple trees in mid-October. Within eight days numbers had increased to 20,000, and the birds overflowed to neighboring areas where they favored maples, pines and spruces. Rapid changes took place as the deciduous trees lost their leaves and the birds abandoned them for trees which still had some cover. Another fall grackle roost, a

grove of elms on the college campus at Grinnell, Iowa, was mentioned by Conard (1932), who kept a record of the great mortality there in 1931. Between September 18 and November 29 Conard collected and counted 451 dead grackles. In addition, before counting began, an employee of the college had gathered three bushels of the dead birds. Although robins roosted in adjacent trees, none were ever found dead. No reason was known for the mortality among the grackles.

In the most complete study made to date on grackle roosting, Monk (1933) summarized the activities of the grackles for a 16-year period at Nashville, Tennessee, where the birds used various places as roosting sites, chiefly in Centennial Park. He thought it impractical to distinguish roosts according to season, because the same habit was involved at all times, and because spring roosts overlapped summer roosts and summer roosts overlapped those used later. Spring roosts included a haw thicket in Centennial Park, a grove of magnolias on the campus of Fisk University, several honey locusts at the edge of the park, and a clump of cedars four and one-fourth miles from the city limits. These spring roosts extended into the breeding season, were widely separated, and rarely exceeded 500 birds. Although they were usually some distance away from the nesting sites, one was discovered in which about 25 pairs of grackles nested.

Further observations by Monk (1933) indicated that after the nesting season a favorite roosting site was a double row of maples along a drive in the park. As the population of birds increased the excess overflowed to other trees nearby, as well as to trees on islands and shores of a lake in the park. Usually about 5,000 birds comprised the Centennial Park roost by mid-summer. In some years a grove of young trees

trees in the rear of the Father Ryan High School was the early summer roost, and a thick stand of shade trees in a residential area, at a place called Stratton Home, was another. In fall the Stratton roost extended over 10 city blocks, while the Centennial Park covered 12 acres of closely planted trees, and contained about 100,000 grackles plus an equal number of other species. In late fall the birds moved from the deciduous trees of the park to the conifers of Mount Olivet Cemetery where they stayed until migrating. On several occasions winter roosts with 50,000 birds were established after the bulk of the migrants had left the park. The site chosen, now bare of leaves and exposed to the elements, was the same thicket which was used for spring and early summer roosting; but the growth was dense, gave protection from predation, and permitted the birds to roost together. Monk mentioned that three species of birds were present, but did not name them.

Monk (1933) found starlings, cowbirds, purple martins, red-wings, English sparrows, and robins associated with the grackles, but he never saw more than five species together at any one site. Since he knew of cedar waxwings flying with the grackles at dusk, he thought it reasonable to expect them to be present in the roost too, as well as rusty blackbirds, though he had not identified either species there.

Emlen, J. T. (1934) described a 30-year stand of hemlock and pine near Cresheim, Pennsylvania, which served as a grackle roost from early spring until nesting season. The birds preferred the hemlocks, and used the upper branches, which were 20 to 30 feet above the ground, as their sleeping sites. An estimated 50,000 grackles were present during the

middle of March in 1930, though peak numbers were not reached until the last week of the month. Nice (1935) mentioned shade trees in a residential district of Columbus, Ohio, as the site for a fall grackle roost.

Roosts wherein grackles were not most abundant, or for which relative abundance was not given

Willow thickets, used primarily by purple martins, were also summer roosting sites for grackles, cowbirds, and bank swallows, according to Widmann(1884, 1898). In various years roosts were formed on Arsenal Island, Gabbert Island, and near the mouth of the Missouri River, all near St. Louis, Missouri. The willows were 10 to 20 feet high, and grew as dense as one sapling per square foot. Roosting on Gabbert Island occurred in the upper branches of the trees, in an area of 20 acres where the willow stand was the thickest. Purple martins were said to be abundant beyond computation, but no numbers were mentioned for any of the three species of birds present.

Keyes (1888) was greatly impressed by the fall congregations of bronzed grackles, rusty blackbirds, and red-wings which roosted in woodland or marshes near Burlington, Iowa. The species were present in about equal numbers. Migrants from the north apparently joined the local birds early in October, and by the middle of the month the numbers were enormous. Keyes estimated that a single flock he saw must have had about 20,000,000 birds.

In one of the earliest articles concerned with summer robin roosts, Brewster (1890) stated that most of them contained birds other than robins, including bronzed grackles, cow buntings, swallows, cowbirds,

red-wings, kingbirds, orioles, cedar birds, and brown thrashers. He made his observation in Massachusetts where roosts usually were located in swampy, low-lying woods composed of maples, oaks, chestnuts, birches, and sometimes pines. The birds apparently were not concerned with the size of the trees, but dense foliage seemed to be necessary for a site to be selected.

Several summer roosts, wherein grackles did not predominate, were mentioned by Kalmbach and Gabrielson (1921). In the roost at Orange, New Jersey, where the population reached an estimated maximum of 8,000 birds, the starlings outnumbered the grackles three to two. This roost also included some robins, and consisted of tall elms and maples along roadways and dooryards. Another roost at Hartford, Connecticut, contained a population of approximately 5,000 startlings and grackles, and was located on a main residential street. Freehold, New Jersey, had a mixture of starlings, grackles, and robins; and Washington, D. C., in trees on the Mall, had a mixed roost of 8,000 or more purple martins, 1,000 grackles, 300 starlings, and a few swallows, probably rough-winged swallows.

Stoddard (1923) mentioned a late summer sparrow roost in which many robins, purple martins, and grackles were present. It was situated near the zoo in Washington Park, Milwaukee, Wisconsin, and consisted of a small grove of deciduous trees which the sparrows left after the other species had gone south. Wallace (1926) noted mixed roosting during spring migration, and grackle roosting, presumably later in the year, in a thicket near the river in Tuscarawas County, Ohio.

The predominance of the species in a roost may reverse itself,

according to Ewing (1924) who saw this occur in the fall roosts in Washington Zoological Park at Washington, D. C., one year, and in Takoma Park, Maryland, the next. In both years after thousands of grackles had established the roost, starlings joined them in ever increasing numbers until eventually they predominated. Ewing believed that starlings did not roost in immense flocks unless grackles were present.

Very close to a sun porch in Fairfield, Iowa, robins roosted in buckthorn bushes, Rhamnus cathartica, according to Clarke (1930, 1931). Bronzed grackles tried to roost there too, but were driven off by Clarke who believed they distressed the robins. The roost included 25 to 60 robins in the course of several years, but no numbers for the grackles were given.

Bailey (1932) observed fall mixed roosting in box-elders, cottonwoods, willows, and maples at Homewood, Illinois. This roost had been in use for three years and contained starlings, robins, grackles, English sparrows, and a few purple martins. Although he estimated 1,000 as the starling population, he gave no figures for the other species.

Several mixed roosts in reeds and sedges were observed by Emlen, J. T. (1934), who believed that the most numerous species present selected the sleeping site. He noted that only a few hundred grackles, cowbirds, and rusty blackbirds were present with numerous red-wings in the sedges along a drainage ditch at Delaware City, Delaware; and he observed that he never saw more than 30 grackles for every 100 red-wings in the Renwick marshes near Ithaca, New York. He stated further that he had never seen grackles roosting alone in reeds, or a reed roost wherein grackles were in the majority.

Odum and Pitelka (1939) described the early spring mixed roost on the south campus of the University of Illinois. The roosting site was the northern half of a 70-year old 13-acre grove, with open country on its south and west. Usually the birds roosted in a strip of white pines on the northwest side, but sometimes some of the birds used the deciduous trees to the east which were sheltered from prevailing winds by the pines. The pines were present with a density of 250 trees per acre, whereas the deciduous stand, chiefly green ash, was somewhat less dense. Mortality during a storm disclosed that the grackles and cowbirds had used also a small group of tall Norway spruces a little distance from the main roost. Of the 25,000 birds present, approximately 97 per cent were starlings, and the remainder included equal numbers of grackles and cowbirds, together with a very few red-wings.

A spring and fall roost in a sheltered narrow valley at Clay's Ferry, Kentucky, was studied by Loefer and Patten (1941). The site, a three-acre area, was hemmed in on all sides by the rocky walls and slopes cut by the Kentucky River, and was about 100 feet below the level of the surrounding countryside. The deciduous trees near the river were fairly tall, whereas the trees farther away were shorter and included some cedars. Birds were so numerous here that many limbs were broken, and dung was four inches deep in places. Estimates of the population by local bird students varied from 500,000 to several million birds. Starlings out-numbered grackles at least 25 to one in March when the study was made, and a number of cowbirds were present the earlier part of the month. The roost had been used the entire winter prior to the study, probably because the weather had been mild, but all birds were gone by the end of March.

Estimating Bird Populations

Only a few writers have given any indication of the methods they used to arrive at the numbers they published. Jones (1897) tried to get population estimates by counting the grackles in sight and observing the appearance of the trees before the bulk of the birds arrived, and doing the same after the last birds were in the roost. He also timed the passage of a flight and counted the number of birds abreast in the flock. In his work with starlings, Wynne-Edwards (1929a) attempted to count the birds per square yard in the trees, then used the dimensions of the roost to compute the total number present.

Several writers have questioned the validity of some population estimates or declared them exaggerations (Evans, 1925; Nicholson, 1932; Marples, 1934).

Life Span of Roosts

Although many writers did not mention the age of the roosts that they described, or merely indicated that they had existed for some time, somewhat more concrete data were given by others. Jones (1897) recorded roosting at Oberlin, Ohio, from the early 1880's to 1896 when he terminated his study, and Widmann (1898) indicated that each of the willow thickets near St. Louis, Missouri, were used several years in succession. The Overbrook roost in Philadelphia, Pennsylvania, was used for more than 20 years (Peck, 1905), and one near Concordville, Pennsylvania, for at least 25 (Palmer, S. C., 1906). Potter (1912) gave 40 years for the

roost at Germantown, in Philadelphia, and 30 years for the one at Swarthmore, Pennsylvania; Rhoads (1913) listed 14 years for the one at Snow Hill, New Jersey. Monk (1933) described the history of roosting for 16 years in Nashville, Tennessee, and Loefer and Patten (1941) stated that the spring and fall roost at Clay's Ferry, Kentucky, had been in use for seven years prior to their study. Nesting season roosts had very indefinite life spans according to Monk (1933), who found that they might change from year to year, or even from week to week. Marples (1934), in his survey of starling winter roosts in the British Isles, mentioned one roost used for 180 years.

Roosting Flights

An early observation on the behavior of grackles in flight to their roost was made by Nuttall (1840) who believed that each group of birds had a leader which selected the intended spot. However, detailed observations on grackle roosting flights were not recorded until Jones (1897) published the results of his three-year study. Jones, as well as Widmann (1898), noted that the birds came to roost each evening from a definite direction, but according to Jones this direction was not necessarily the same year after year. It was related to the location of other roosts and to the area where the birds foraged during the day, for each group of birds had its own feeding grounds as well as own roost. Evidence indicated that the birds followed landmarks, at least for part of the way, for when they roosted in the eastern part of Oberlin, Ohio, they completed their flight by following Plum Creek. Several years later the tall

steeple of a church seemed to serve as a guide.

Certain weather phenomena were found to influence the flights (Jones, 1897). The direction of strong winds, for instance, was found to have considerable bearing on the numbers of birds that arrived from some directions. When strong winds blew from east or north, more birds than usual came from those directions, but when the wind came from south or west, almost no birds came from east or north. Jones concluded that such birds as had wandered too far from other roosts came to Oberlin rather than fly against the wind to return to their own sleeping sites, and that Oberlin birds resorted to other roosts under similar circumstances. On the other hand, strong winds from the north had no obvious affect on the incoming flight from the south, presumably because it was too large and too well organized to be changed by the weather.

Jones (1897) believed that there was a close relationship between the varying lengths of the days and the time of daily arrival and departure of the grackles, after due allowance for cloudy weather and storms had been made. Cloudiness, he found, retarded morning departure but hastened evening arrival, and thunderstorms after four o'clock caused the grackles to leave their foraging grounds early, in order to fly to the roost before the storm burst.

The altitudes at which the birds flew on their way to and from the roost, as well as the size of the flocks, received some attention from Jones (1897). During September, 1895, he observed that most birds just skimmed the trees, though a few groups came at considerable elevation. On May 23, 1896, he noted that 90 per cent of the birds that came to

the roost flew low among the trees, one to ten birds every few seconds; and the other 10 per cent flew at approximately 100-feet elevation, in smaller companies or as individuals. On July 17, 1896, the evening flight came in for an hour at the rate of 52 birds per minute, and then finished when a large group of uncountable numbers arrived. Jones used several methods to estimate over 5,000 grackles in the roost that night. A morning flight on September 7, 1896, was very near the ground, the lowest birds within 20 feet of it. This flight was one continuous stream of birds which rose to clear buildings and woods and then returned again to their former level. The evening flight of that same day got under way gradually for about 20 minutes. During the next 11 minutes about 5,000 birds arrived, in groups of 200 to 800, and a little later over 600 came to the roost to complete the flight.

Several other writers mentioned the altitudes of the flight lines. Widmann (1898) observed that the grackles approached Gabbert Island near St. Louis, Missouri, at several hundred feet altitude, and Rhoads (1913) estimated an elevation of approximately 120 feet for the birds at the Snow Hill, New Jersey, roost on August 31, 1913.

Further observations indicated that small flocks gradually combined to form one huge flock, with some stragglers, as the season advanced (Jones, 1897). The huge flock had very characteristic shapes. It was always elongated parallel to the line of flight, and usually had alternate bulges with many birds and narrow parts with few birds. Sometimes there were no narrow places and the whole flock was shaped like a spindle, blunt at one end. A bulge seemed to be produced whenever a section of

the flock, which had stopped to rest until the other birds had passed over, suddently rose to bring up the rear.

According to Peck (1905) grackles came to the Overbrook roost at Philadelphia, Pennsylvania, as family units in July, and no flight lines were formed until early in August. In September and October great flights began about 5:30 P. M. and lasted for 20 to 25 minutes, but scattered birds continued to come until dark. On October 2, 1905, a morning flight was observed which left the roost as a single flock which took 10 minutes to pass. Robins were noted to leave the roost in scattered groups 15 to 30 minutes before the grackles. Palmer, S. C. (1906) noted that robins were never in compact groups like those of the grackles and cowbirds, and similar conclusions were reached by Brewster (1890), Torrey (1890), Stover (1912), and others.

Reports from various observers showed that the directions of flight lines varied from one roost to another (Potter, 1912), yet were permanent for each roost. Up to the middle of June the grackles came to the roost from all directions, according to Potter, but when the nesting season was over they began to form flight lines. These were quite definite by the last week in June, and were then followed by the flocks of the birds, although some individuals might come in from any direction. Potter gave maps showing the flight lines for the roost at North Woodbury, New Jersey, and showed that some of the birds had several important gathering places before they finally came to the roost. Emlen, J. T. (1934) observed that the birds sometimes lit in fields or on lawns to eat before making the last part of their flight.

Comments in the summary by Potter (1912) indicated that the numbers of the birds along the flight lines had been known to vary greatly, even within a very few days, which signified probable shifts in the location of feeding grounds. Grackles were believed to start for the roost about the same time each evening, regardless of where they had been feeding, and those nearest the roost reached it first.

In his description of flights during the nesting season, Monk (1933) decided that the grackles did not always go to the nearest roost, but that they did set a straight unbroken course for the site of their choice. Flights during the nesting period were usually composed of birds in pairs or alone, or occasionally in groups of three or four birds, and seldom in large flocks. On April 9, 1926, for instance, 75 per cent of the birds going to the roost in Centennial Park at Nashville, Tennessee, came in pairs, while on May 17 the flight consisted of groups of two or three grackles with a few groups of six or eight. With the advancing season the roost and the size of the flocks increased concomitantly, and on June 19, 1918, Monk saw a flock of 20 birds, whereas on June 30 he saw flocks of 30 to 50. Shifts of roosting sites were not uncommon in Nashville, but the author noted that the birds would sometimes continue to fly over the old site on their way to a new one.

Ewing (1924) noted that the composition of the flocks in October changed during the course of the evening at Takoma Park, Maryland, and at Washington, D. C. For the most part the first flocks were entirely starlings or grackles, but later in the evening nearly all flocks were mixed, though starlings predominated.

A pioneer study of the relationship of light intensity to the time of roosting flights was made by Nice (1935). On nine mornings and five evenings during October, 1934, she noted the time of the flights and measured zenith light with a Weston photometer. Nice found a very close relationship between the light intensity and the time of exodus or arrival of the birds. Starlings left the roost at lower light values than the grackles; and they left at greater light intensities when the temperatures were low than when they were high.

The starlings and grackles of the early spring roost at Clay's Ferry, Kentucky, apparently did not follow definite flight lines, for Loefer and Patten (1941) remarked that the flocks came from all directions. The birds began to appear near the roost as early as six o'clock in March, 1941, after they had come from distances of 10 to 15 miles, and converged upon the area in small flocks which combined into larger ones. Migrating flocks as well as local birds probably were present.

The Birds at the Roosts

Various observations have been made of the behavior of grackles and their associates at the roost. Maynard (1881) early noted that the birds were quite watchful, even on dark nights, and Bendire (1895), and Kalmbach and Gabrielson (1921) called attention to the deafening noise made by the mixed birds at the roost.

Jones (1897) concluded from his observations at Oberlin, Ohio, that the male grackles did not roost near the brooding female many nights, but soon joined other males at the late spring roosting site. Young

birds came with the males as soon as they were able, and the females joined the roost when nesting duties were over. Parental duties continued, however, and young birds were fed for some days, even during the evening within the roost. Similar conclusions were reached by Emlen, A. C. (1902), and Potter (1912). Monk (1933) thought that late nesting pairs used the spring roost until nesting duties kept the female on the nest, but that the male birds continued to go to the roost.

The first birds to reach the roost did not behave in the same manner as late arrivals (Jones, 1897). Early grackles, for instance, did not settle into the foliage until they had perched at the very tops of the trees for some time, whereas later arrivals entered the tree crowns immediately. Early cowbirds met with some opposition from the grackles, according to Jones, and were not permitted to enter the roost until later in the evening. They remained in nearby trees until the grackles began to settle for the night, then made a dash for the roosting site, and no longer were molested. Early arrivals at the Snow Hill, New Jersey, roost seemed to reconnoiter before alighting in the trees, according to Rhodes (1913), probably because of shooting by hunters. Late birds entered the roost directly.

Emlen, J. T. (1934) observed that grackles generally roosted in the upper branches, regardless of the size of the trees. Furthermore they were not as easily disturbed as starlings, nor as orderly and dignified in their roosting as were crows. They were late risers, he believed, with morning dispersals more hurried than their evening gatherings. Specific examples of the time and order of arrival and departure of

several species of roosting birds were given by Jones (1897), and Rhoads (1913).

Several writers made comment about the molting of the grackles. Jones (1897), for example, was firmly convinced that the molt was directly responsible for forming the roost. He observed that the summer molt began about June 14, and that all feathers were fully replaced early in October. Peck (1905) noted that the grackles were still molting at Philadelphia, Pennsylvania, in the middle of September, and that the adult birds were later than juveniles in completing the molt.

Causes for Change of Sites

It has not always been clear why grackles and their associates sometimes have changed roosting sites, but a few writers have given apparent reasons for some of the shifts observed. Widmann (1898) believed that the purple martins, and therefore the associated grackles, left the thickets near St. Louis, Missouri, whenever the willows matured and consequently became unsuitable. The birds changed sites when the roost at Media, Pennsylvania, was destroyed by a storm (Omensetter, 1905); when the former site at Concordville, Delaware, was trimmed and the underbrush removed (Palmer, S. C., 1906); and they left the white pine plantation at Norwich, New York, because of the death of the trees (Stewart, 1933).

Early spring roosts in the Delaware Valley were abandoned by April and May, according to Potter (1912), presumably because of migration and nesting; and the trees were deserted in late fall at Berwyn, Pennsylvania, when they lost their leaves (Burns, 1926). Some changes in sites occurred

when smaller roosts combined to form larger ones (Potter, 1912 and Monk, 1933), and other shifts were noted at Nashville, Tennessee, whenever the roost became overcrowded (Monk, 1933).

Persistent molestation by shooting has resulted in the desertion of a number of roosts, and has been a method frequently tried for control purposes. Shooting caused the birds at Oberlin, Ohio, to change roosting locations twice, according to Jones (1897), and shooting was responsible for the desertion of a roost at Media, Pennsylvania (Omensetter, 1905). According to Kalmbach and Gabrielson (1921) several roosts were deserted in New Jersey and Connecticut because of systematic campaigns in which shotguns were used; and at Montclair, New Jersey, the birds were driven out with the use of blank cartridges only.

Roman candles successfully drove the birds away from a roost at Hartford, Connecticut, and incandescent lights within a tree gave local relief at Orange, New Jersey (Kalmbach and Gabrielson, 1921). Streams of water from a fire hose (Kalmbach, 1928), as well as drastic trimming of trees to remove favorite perches (Kalmbach, 1945), were used with some success against starlings. Various suggestions for control of roosts were found in Kalmbach and Gabrielson (1921), McAtee (1926), Kalmbach (1928), Stewart (1933), and Kalmbach (1945). Cursory efforts in roost control have met with little success (Emlen, A. C., 1902; Kalmbach and Gabrielson, 1921; McAtee, 1926).

Economic Importance of Roosting

The roosting of thousands of grackles and associated birds has had its economic consequences, as shown by several authors. McAtee (1926),

for example, gave a grief but quite complete summary of the undesirable characteristics of grackle roosts when he stated (pages 373 to 374):

> The objectionable features of these congregations include noise which wakens people earlier in the morning than they wish, or even keeps them awake most of the night; the driving out of other birds; copious droppings from the birds which render passage on sidewalks under the roosts very disagreeable, and makes it impracticable to spend evenings outside of houses in the roosting areas; the accumulation of filth, largely excrement, which kills grass, and, especially in wet weather, produces offensive odors; and actual damage to trees by the breaking off of branches. In some cases the presence of Blackbird roosts is said to have seriously depreciated the value of residential properties.

McAtee (1926), a biologist with the United States Bureau of Biological Survey, received many complaints about gregarious roosts in various communities in the states of Iowa, Kansas, Missouri, Illinois, Indiana, Ohio, Kentucky, Tennessee, Pennsylvania, Virginia, Maryland, Delaware, New Jersey, and New York. McAtee could offer no definite reason for the latitudinal arrangement of the roosts, but suggested that probably the blackbirds roosted in the marshes of the Gulf Coast and of the Great Lakes region, and that perhaps the birds did not congregate in large roosts in the areas between the marsh roosts and the belt described.

Stewart (1933) believed that roosting blackbirds, starlings, and other birds caused the death of about two acres of white pines near Norwich, New York. A chemical analysis of the soil beneath the affected trees, and of nearby normal areas, showed excessive quantities of nitrates beneath the dying trees as the only significant difference. Marples (1934) listed a number of trees and bushes that had been affected adversely by starlings in the British Isles, but said that in most roosts the trees were affected little, and that laurels actually seemed to

benefit. According to Emlen, J. T. (1934), the droppings of starlings destroyed leaves of hardwood trees, but since the leaves were not affected materially until the end of the season, the trees ordinarily were not killed.

Though many people have complained about grackle and starling roosts, some have derived pleasure from them. Emlen, J. T. (1934) found that the people at Cresheim, Pennsylvania, enjoyed the presence of a roost, and called local police on the scene when it was molested.

HISTORY OF ROOSTING IN AMES

The past history of the roosting of grackles and their associates in Ames was available primarily from citizens who had lived near the roosting sites. Few of these people had any strong interest in bird study or had kept any written records, but the information they gave indicated that the birds had roosted in Ames for about 30 years. The roosting ordinarily was very local, since the birds usually were present in moderate numbers.

Concentrations of grackles were said to have roosted in the 700-block on Clark Avenue, and on the 800-block on Wilson Avenue, at least since the early 1920's, though apparently not for some years immediately preceding the present investigation. They left this general locality when a number of large box-elder trees were removed from the east side of the 800-block on Wilson Avenue. Some grackles appear to have roosted in the American elms on the corner of Eighth Street and Clark Avenue during the late 1930's, and small groups of the birds may have roosted in the black maples near the corner of Eighth Street and Duff Avenue in 1946 and 1947.

More details were available about roosting which occurred in the west part of Ames from 1934 to 1948. During this time sites for the birds included parts of the residential area south of the Iowa State College campus, as well as that portion of the campus along Lincoln Highway from the Cranford Apartments on the west to the girls' dormitories on the east. They roosted south of Music Hall and Alumni Hall, near the girls'

dormitories and eastward along College Creek, south of the railroad tracks and northeast of the Memorial Union, and some even roosted as far north as the southeast corner of the Veterinary Quadrangle. Although in most years the birds concentrated near the Memorial Union and Lincoln Highway, in 1948 they extensively occupied all of the territory listed.

When roosting built up to nuisance proportions during the latter part of September and the first part of October, 1948, college authorities and the local conservation officer made serious efforts to break up the roost. At first Roman candles were tried, and while successful at certain sites, they could not reach the birds in the taller trees. Then shotguns were used intermittently for about two weeks, with as many as 20 men operating on some evenings. On the first evening no shots were fired until the birds were settled in the roost, but on other days the shooting was earlier. One observer estimated that several thousand birds were killed, mostly grackles, and another believed three bushels of birds were picked up after the first night's shooting. Many cowbirds and starlings were among the victims. After the shooting campaign the birds resorted to the residential areas of the town. Those birds that tried to roost south of the campus were further molested by fraternity men, who continued to shoot at them until stopped by local police.

The control efforts were successful in breaking up the roost, for not only did the birds leave after the shooting in 1948, they did not return to the campus to roost in 1949. However, another event may have had a bearing in helping to keep the birds away in 1949. After the birds had been driven off the campus in October, 1948, a stand of ash trees on

the campus near the Cranford Apartments, was cut down. While only a small part of the total roost, they had been used extensively by the roosting birds.

Local and limited roosting on the campus in 1951 and 1952 was said to have occurred in the trees near the girls' tennis courts, though it was never observed by the writer.

OBJECTIVES

Preliminary observations made in late summer and fall of 1949 revealed that the bronzed grackles and their associates went to roost, night after night, in certain definite areas in Ames, and did not choose a different place each time. Furthermore, the birds did not seem to select trees indiscriminately, but resorted to the same specific trees each night. It was also noted that several flight lines, which seemed to follow very definite paths, led into Ames the same time each evening. Nevertheless, over a period of weeks some changes were noted, new areas were used by the birds, former roosting sites were abandoned, the flight lines changed somewhat, and weather seemed to exert some influence. Further observations, both at the roost and along the flight lines, showed that certain behavior patterns of the birds occurred repeatedly.

The present investigation, therefore, was planned with several objectives in mind:

1. To learn whether or not certain readily measurable features of the roosting sites were correlated with the extent to which they were used by the birds.
2. To learn whether or not readily measurable weather phenomena were correlated with the behavior of the birds.
3. To observe the responses of the birds to interference by people.
4. To add to our knowledge of the natural history of the bronzed grackles and their associates.

DESCRIPTION OF THE STUDY AREAS

During the years 1949 to 1952, when the present investigation was in progress, the birds roosted primarily and extensively in the residential district in northeast Ames. In 1949, the year after the shooting campaign on the campus, they also roosted widely in the residential section south of the college; but in 1950 the birds resorted to this neighborhood less and less, and in 1951 and 1952 they used it hardly at all. The two areas, which are shown in Figure 1, have been called "northeast Ames" and "southwest Ames" respectively in this study.

Although northeast Ames was considered to be the chief study area, and nearly all data gathered were secured here, southwest Ames was examined repeatedly since it had been used extensively during the first year of the investigation. The boundaries of the two areas were chosen to include nearly all roosting sites found, as well as nearby territory wherever possible.

The northeast Ames study area was a residential district approximately nine-tenths mile long from east to west, and about nine-tenths mile wide at the widest part from south to north. It extended from Crawford Avenue and Maxwell Avenue on the east to Northwestern Avenue and Curtiss Avenue on the west, from Main Street and Fifth Street on the south to Thirteenth Street on the north, and in addition included on the north a small section from Thirteenth Street to Sixteenth Street and between Duff Avenue and Burnett Avenue.

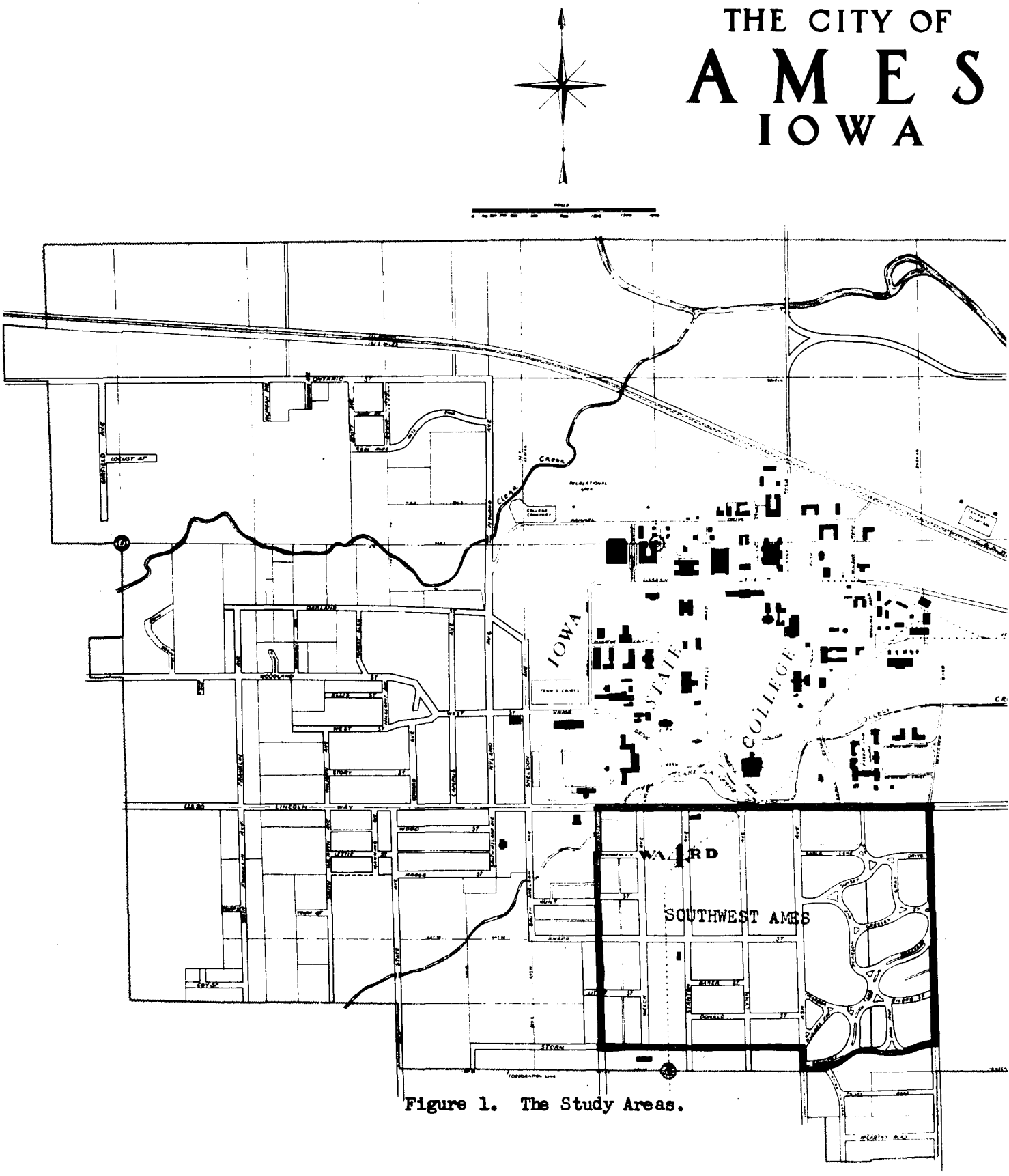
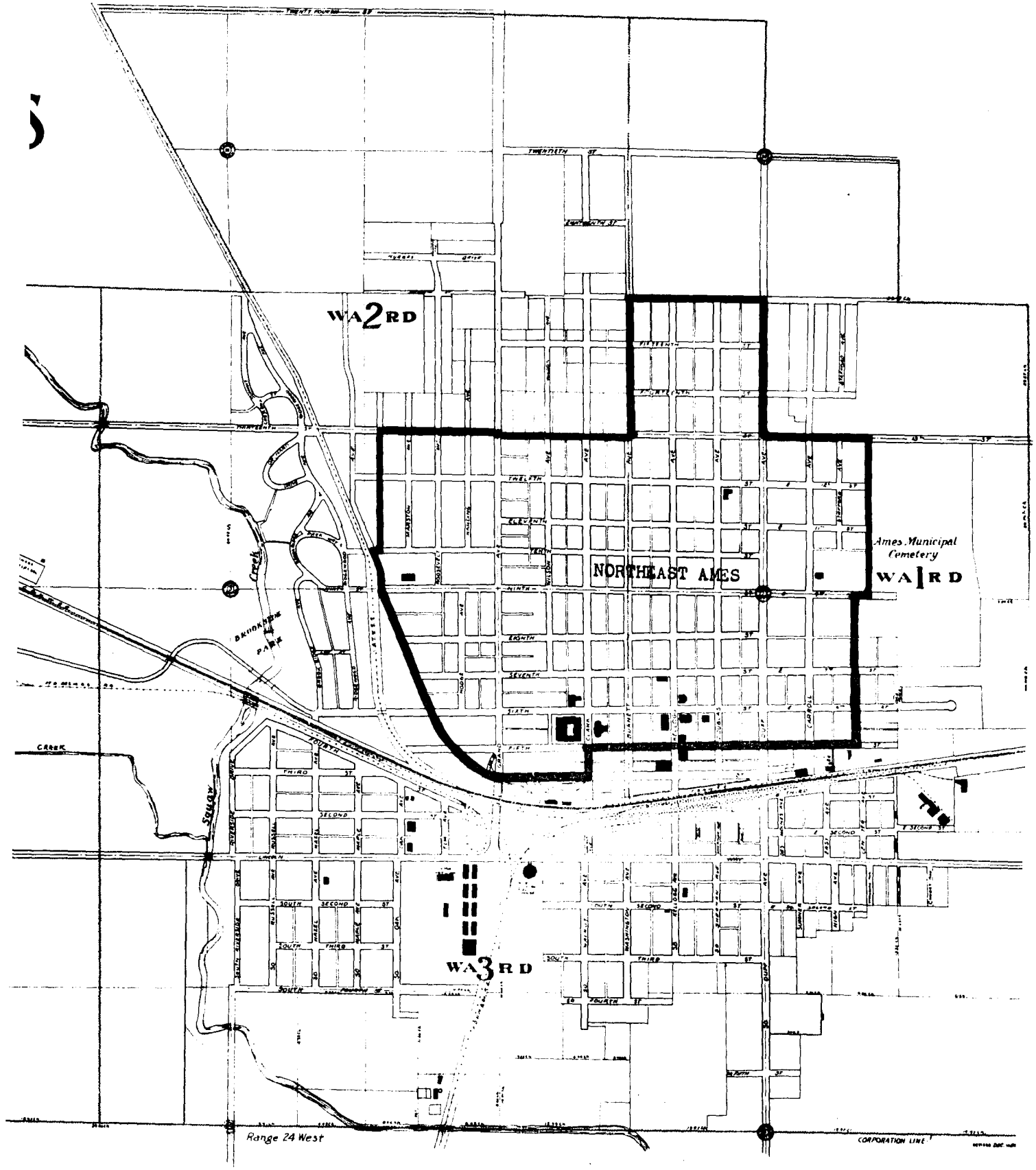


Figure 1. The Study Areas.


WA2RD
NORTHEAST AMES
WA1RD
Ames Municipal Cemetery
WA3RD
Squaw Creek
Range 24 West
CORPORATION LINE

Two main thoroughfares crossed northeast Ames from south to north: Grand Avenue or Highway 69 in the western part of the study area, and Duff Avenue in the eastern part. East-west streets which carried fairly heavy traffic included Main, Fifth, Sixth, and Ninth Streets. Ninth Street almost divided the area into halves, and the other streets were in the southern part near the business district of Ames. This entire study area, essentially level with a slight rise in elevation both northward and eastward, was approximately 925 feet above sea level.

Except for extent, there were no obvious differences between the stands of trees in northeast Ames and the stands found immediately south in the southeastern part of the city. Despite this the birds used northeast Ames as an extensive roost, yet used the southeastern part of the city only as a stopping place, or not at all. Exceptionally, local roosting did occur in southeast Ames for very short periods of time.

Many of the trees in northeast Ames were 40 to 50 or more feet tall, and some were as tall as 90 to 100 feet. Nearly all of the taller trees were planted along the streets, and most of the shorter trees were in back yards. Table 1 lists the species of trees found in this area.

Southwest Ames was a somewhat smaller study area, about seven-tenths mile long from east to west and about four-tenths mile wide from north to south. It extended from Beech Avenue on the east to Hayward Avenue on the west, and from Lincoln Highway on the north to Storm Street on the south. The heaviest east-west traffic occurred on Lincoln Highway and Knapp Street, and the heaviest north-south traffic was found on Welch Avenue and Ash Avenue. This area had greater differences in elevation than were found in northeast Ames, and had a general elevation about 35

Table 1. Species of trees in northeast Ames.

Common name	Scientific name*
Apple, Common	Pyrus Malus Linnaeus
Apricot	Prunus Armeniaca Linnaeus**
Arbor Vitae, American	Thuja occidentalis Linnaeus
Ash, Green	Fraxinus pennsylvanica lanceolata (Borkhausen) Sargent
Basswood	Tilia americana Linnaeus
Birch, Paper	Betula papyrifera Marshall
Box-Elder	Acer Negundo Linnaeus
Buckeye, Ohio	Aesculus glabra Willdenow
Butternut	Juglans cinerea Linnaeus
Catalpa, Common	Catalpa bignonioides Walter
Cedar, Red	Juniperus virginiana Linnaeus
Cherry, Sour	Prunus Cerasus Linnaeus
Cherry, Sweet	Prunus Avium Linnaeus
Coffee-tree, Kentucky	Gymnocladus dioica (Linnaeus) Karl Koch
Cottonwood	Populus deltoides Marshall
Crab, Wild	Pyrus ioensis (Wood) Bailey
Douglas-Fir	Pseudotsuga taxifolia (Poiret) Britton**
Elm, American	Ulmus americana Linnaeus
Elm, Chinese	Ulmus parvifolia Jacquin**
Elm, Siberian	Ulmus pumila Linnaeus
Elm, Slippery	Ulmus rubra Muhlenberg
Hackberry	Celtis occidentalis Linnaeus
Hawthorn, Downy	Crataegus mollis (Torrey & Gray) Scheele
Honey-Locust	Gleditsia triacanthos Linnaeus
Hop-Hornbeam, American	Ostrya virginiana (Miller) Karl Koch
Horse-Chestnut	Aesculus Hippocastanum Linnaeus
Larch, American	Larix laricina (DuRoi) Karl Koch
Locust, Black	Robinia Pseudo-Acacia Linnaeus
Maple, Black	Acer nigrum Francois Michaux

* According to Fernald (1950) unless otherwise designated.

** Not listed by Fernald (1950). Name as given by Rehder (1947).

Table 1. (Continued)

Common name	Scientific name
Maple, Norway	Acer platanoides Linnaeus
Maple, Silver	Acer saccharinum Linnaeus
Mountain-ash, American	Pyrus americana (Marshall) DeCandolle
Mulberry, Red	Morus rubra Linnaeus
Mulberry, White	Morus alba Linnaeus
Oak, Burr	Quercus macrocarpa Michaux
Oak, Pin	Quercus palustris Muenchhausen
Oak, Northern Red	Quercus rubra borealis (Francois Michaux) Farwell
Olive, Russian	Elaeagnus angustifolia Linnaeus
Peach	Prunus Persica (Linnaeus) Batsch
Pear, Common	Pyrus communis Linnaeus
Persimmon, Common	Diospyros virginiana Linnaeus
Pine, Austrian	Pinus nigra Arnold
Pine, Red	Pinus resinosa Aiton
Pine, Scotch	Pinus sylvestris Linnaeus
Pine, White	Pinus Strobus Linnaeus
Plum, Garden	Prunus domestica Linnaeus
Poplar, Bolleana	Populus alba pyramidalis Bunge**
Poplar, Lombardy	Populus nigra italica Muenchhausen
Spruce, Blue	Picea pungens Engelmann**
Spruce, Norway	Picea Abies (Linnaeus) Karsten
Sumac, Smooth	Rhus glabra Linnaeus
Sumac, Staghorn	Rhus typhina Linnaeus
Sycamore	Platanus occidentalis Linnaeus
Tree-of-heaven	Ailanthus altissima (Miller) Swingle
Tulip-tree	Liriodendron Tulipfera Linnaeus
Walnut, Black	Juglans nigra Linnaeus
Willow, Weeping	Salix babylonica Linnaeus
Yellowwood	Cladrastis sinensis Hemsley**

feet higher. The section west of Ash Avenue was quite level, with a rather sharp descent northward to Lincoln Highway from a line extending approximately from Hunt Street to Sunset Boulevard. As suggested by the winding roads shown on the map, the section east of Ash Avenue was quite variable in elevation.

If the southwest area is considered as a whole, there were probably several ways in which it differed from northeast Ames. As can be seen from Figure 1, many of the blocks were longer in southwest Ames than in northeast Ames, and therefore the rows of trees along the streets were longer. Back yards in the southwest study area contained more large trees planted in irregular pattern, while on the contrary the back yards of northeast Ames were comparatively more open, with smaller trees if any were present at all. In addition there were many more coniferous trees in southwest Ames, but they occurred in rather concentrated local groups. On the other hand, if one considers only those places used as roosting sites in the two study areas, the differences were not so great, and the length of the blocks was the greatest obvious difference.

METHOD OF PROCEDURE

Definition of Terms and Abbreviations

In the literature about roosting a number of terms were used which overlapped broadly and had no precise meaning. To meet the needs of the present investigation, these terms, and several others, are limited to designate specific ideas, and in the present and succeeding sections they are used as defined. The meanings of some frequently used abbreviations are also given.

1. Black maple--This term has been used to include the true black maple as well as the few sugar maples (Acer saccharum Marshall) and the intermediate forms present in Ames. Because it was frequently an arbitrary decision to decide what species to call one of these trees, all were lumped together for purposes of the present investigation.
2. DBH--Diameter of a tree at breast height, measured in inches.
3. Degree of use--An index of the number of birds that used a roost tree. The degrees used in this investigation were: none, light, moderate, heavy.
4. Flight--This term has been used in two ways, (a) the general phenomenon of the birds flying toward the roost, and (b) the sum total of all birds which came into Ames from a fairly specific direction. In the latter sense, for instance, there were several flights: a north flight, a southwest flight, and some others.
5. Flight line--The pathway taken by a flight.

6. Hard maple--Either a black maple, a Norway maple, or a sugar maple.

7. L&M&H--Abbreviation for the sum of the data under "light", "moderate", and "heavy" degrees of use. This sum is the total number, or total per cent, of trees used for roosting, regardless of degrees of use.

8. N, L, M, H--Abbreviations for the degrees of roosting: none, light, moderate, heavy.

9. Roost--When used as a noun, an area which was composed of one or more roost sites, but broadly separated from other similar areas. Ames was considered to have had two main roosts, one in southwest Ames, and the other in northeast Ames. Several lesser roosts also existed at times.

10. Roost place--A general term which might mean either a roost tree, or a roost site, as determined by context.

11. Roost site--A local area in which the birds roosted. An organic unit, which might include only one roost tree or many, and might even extend over several contiguous city blocks.

12. Roost tree--A tree in which the birds stayed during the night.

13. Stopping place--A tree, or site, in which the birds settled momentarily or longer before they flew to their roost trees.

14. Study area--A large section of Ames which was kept under constant observation.

Keeping Informed About the Roost Sites

General mapping and records

To get data concerning the birds' use of roost sites and roost trees, maps were prepared to show the presence of all roads, sidewalks,

and trees near the sidewalks. These maps were rather crude and quite general. For sake of convenience trees in back yards were omitted, for preliminary observations had indicated that as a whole they were of little importance to the birds. Maps were made first for those city blocks on which the birds were roosting, and for those immediately adjacent. Then, as the birds shifted to new sites, additional maps were made accordingly. Since the shifts involved different amounts of territory, the maps also included varying amounts. No measurements were taken, nor was there any attempt to follow any precise scale. Efforts were made to plot the trees in relatively proper position, with different symbols for the different species, in order that the roosting history of any one tree might be followed. All maps were prepared on standard size typing paper, then were hektographed to get duplicate copies.

Although the work had begun in 1949, mapping was the major task for the summer and fall of 1950. All streets in the northeast study area, and that portion of the southwest area from Ash Avenue westward to Stanton Avenue and from Storm Street northward to Lincoln Highway, were mapped, a total of 238 blocks.

As soon as a map was hektographed, a copy was used to record the location of the roosting birds. The roost was inspected tree by tree; and with the accumulation of droppings to serve as a guide, the appropriate tree symbols on the map were marked with a pencil. At first records were kept only on the basis of whether the trees were used for roosting or not. No attempts were made to distinguish degrees of roosting until a trial early in 1950 revealed that this could be done profitably, even though it was somewhat subjective. Based on the relative accumulation of

droppings, tree symbols were thereafter marked differentially. Seven degrees of use were recorded on the maps, but for final analysis they were consolidated to four: none, moderate, light, heavy.

The roost was examined periodically to study the changes during the season. Since moderate or heavy rains were quite effective in washing away the past accumulations of droppings, the successive inspections were made two or three days after such rains, and three to four weeks apart. Thus only fresh accumulations of droppings were used to determine the extent of roosting, and periodic notes were taken on comparable bases. Conscious efforts were made to have the seven degrees of use designate the same quantity of droppings at each periodic examination.

Since the droppings showed prominently on pavement and sidewalk, the inspections were made from a bicycle. Easily walked or parked almost anywhere, it proved to be a very flexible means of transportation. Streets not used by the birds were passed over in a hurry, and specific trees were examined on foot or merely by coming to a stop near the curb.

To avoid danger from traffic and also to get accurate records, the inspections were made from only one side of the streets at a time. When both study areas were examined completely, over 30 miles of cycling were required, a task which was usually accomplished by noon of the second day.

Detailed mapping and records

Some of the physical features of the roost sites were measured in 1951, and plans were laid to learn more about roosting in trees in back yards. To this end detailed maps were prepared to show back yard trees

as well as street trees. Again they were drawn on standard size typing paper, with only one block on a sheet. On the maps were recorded the distances separating the trees, as well as the dimensions of the street, and in columns at edges of each sheet the heights of the trees and the diameters at breast height were listed. All distances were measured with a 100-foot metal tape, and tree dimensions were secured by standard ecologists' techniques. The heights of the trees were estimated by the hypsometer method, and diameters of trunks at breast height with a Biltmore stick. Distances and heights were taken to the nearest foot, and diameters of trunks to the nearest inch.

Back yard trees were considered to be any trees more than 50 feet from the curbing, but not farther back than the alley in the middle of the block. Near the corners rather arbitrary decisions invariably had to be made to decide whether certain back yard trees should be included on the one street or on the other. The nearness to street trees usually answered the question, though often the grouping of trees seemed more important and helped to determine the placing.

The first blocks to be measured were those on which the birds were roosting. As they moved to new sites, efforts were made to keep up with the birds, and priority when necessary was given to measuring those blocks where the birds had also roosted in 1949 and 1950. Several blocks were measured in anticipation of the birds, since roosting had occurred there the previous two years. The work was kept up throughout the 1951 season, and a total of 47 blocks were measured in detail.

The detailed maps were hektographed, minus the dimensions, and used as field maps together with the more general maps made in 1950. Periodic

bicycle tours through the study areas were made in 1951 and 1952 as they had been made in 1950, but back yard trees, in blocks for which detailed maps were available, were examined on foot. This prolonged the periodic inspections until they required nearly two full days each.

A drought in late summer and fall of 1952 prevented droppings from washing away. Since the dry atmosphere preserved the droppings so well that frequently they could not be distinguished from fresh ones, no inspections on a roost-wide basis were recorded on maps during that time.

Although the dimensions of the trees were secured in only the one year, 1951, records of the roosting use they received were kept for the three years, 1950, 1951, and 1952. Since the trees were measured in the middle year, the assumption was made that the actual dimensions in the other two years were at least relatively comparable to those that were taken. For purposes of comparison, therefore, the 1951 measurements were assigned to the trees for all three years.

Measuring Cover Density

The density of cover, provided by the foliage of the trees, very early was suspected as a factor in the birds' choice of roost sites. To get data concerning this cover, the foresters' method of measuring forest canopy (Morris, 1936; Bacon, 1939; Wright, 1943; and others) was used, though in somewhat modified form. In essence, the method involved measuring the light beneath the trees and then expressing it as a percentage of the light in the open.

A Weston Sunlight Illumination Meter, Model 756, was used to

measure the light intensities. It had three scales; 0 to 100, 0 to 1,000, and 0 to 10,000, all calibrated in foot-candles. Because the sensitive element of this model was equipped with a quartz cover, rather than with a filter, a certain amount of ultra-violet was admitted in addition to the usual radiation in the visible part of the spectrum. Consequently, the light intensities read on this meter were a little higher than other meters would have registered under similar conditions.

Only zenith light, which came vertically through the crowns of the trees, was wanted to get indices of cover density. Side light, which came from reflections from tree trunks or houses, or which came at an angle directly from open sky, was exceedingly variable and not a function of crown density. To eliminate it, a modification of the method employed by Morris (1936) was used. Morris used a metal cone-like shield, open at both ends, with sides at an angle of 60 degrees to each other. With the smaller opening of the proper dimensions to fit over the sensitive element of the meter, and with the sides flaring outward away from the element, the shield admitted light only through a solid angle of 60 degrees. When the sensitive element with cone in position was pointed to zenith, all light beyond 30 degrees from the vertical was completely eliminated. For the present investigation, two orange juice cans, of number three size, were cemented together end for end to make a stovepipe-like arrangement. The upper can had both ends removed, the lower can only one end. They were painted a flat black, inside and out; and a slot, just large enough to permit the entry of the paddle with its sensitive element, was cut on the side of the lower can immediately next to the bottom. A wood

block was glued to the inside bottom in order to keep the sensitive element centered. The "stovepipe", with the sensitive element in position, was supported on a base which was equipped with two bubble levels at right angles to each other. Thus only a cylinder of light could reach the sensitive disk, and it always could be pointed definitely to zenith. The entire assembly, which consisted of meter, base, and "stovepipe" with the sensitive element, was carried by the writer in front of him whenever light measurements were made.

In order to have as little change in the angular altitude of the sun as possible, all cover-density measurements were taken between 11:00 A. M. and 1:00 P. M. They were taken on days when sky conditions were quite uniform, for experience showed that a broadly broken cloud cover gave rapidly changing readings, sometimes even in a matter of seconds. Similar conclusions were reached by Bacon (1939), Sather (1950), and others. Since work by Bacon (1939) indicated that the same per cent of light got through a forest canopy on dark days as on clear days, uniformly overcast skies were used as well as clear skies. Readings were taken on days that were calm or when there was only a moderate breeze. Very windy days were avoided, for strong winds opened and closed the tree crowns rapidly and caused wide fluctuations in the light readings beneath all but the densest hard maples.

Zenith light was measured in the open approximately every 10 minutes during the two noon hours when cover density readings were taken. To get each measure of zenith light on bright days, it was found necessary to take the average of four readings obtained by facing the four cardinal directions. Apparently the flat black paint was not optically flat, and

the "stovepipe" was a little irregular, for slightly different readings were obtained while facing the different directions. No such differences were noted on overcast days, and were not seen beneath the trees.

Twenty readings were taken beneath each tree, the first 10 at arm's length from the trunk, and the other 10 at two arms' length. The meter was read at the end of every step when near the trunk, and at the end of every two or three steps farther out, as determined by the size of the trunk. As the writer called out the values, a helper recorded the readings on special forms. All trees were measured in consecutive order, regardless of the extent to which they had been used by the birds; but since time for these measurements was limited, back yard trees were omitted. Ordinarily it was possible to get readings for all street trees on a block during the two-hour noon interval, and occasionally another block could be started.

It had been hoped to get cover density measurements in 1951, but noon-day sky conditions were exceedingly variable that year. Only five or six noons had uniform sky conditions, not even enough to develop the necessary techniques. Since the weather was considerably more favorable in 1952, a number of readings were taken then.

Measuring Light Conditions in the Roost in the Evening

To get a direct indication of cover conditions that the birds experienced, an attempt was made in 1952 to measure the evening light intensities at the positions where the birds later roosted. The readings were taken on evenings when sky conditions were fairly uniform, from 15

to 30 minutes before the first birds arrived, until readings within the trees approached zero foot-candles.

A strong wood pole, which was made in sections, was used to get readings within the tree crowns. On the uppermost piece a frame was mounted to hold the sensitive element of the light meter firmly in place. Included in the frame was a thin glass plate to give protection against injury from twigs and branches. No "stovepipe" was used in these measurements and the sensitive disk received light from nearly 180 degrees. A long extension cord connected the sensitive element to the meter which was kept on the ground.

Either 10 feet of pole or 20 feet, the latter composed of two 10-foot sections, usually was maneuvered upward toward the spot to be measured, and then smaller extensions, about two and a half feet long, were added as needed. When the entire pole was raised as high as the writer could reach, the sensitive element was about 35 feet above the ground, well within the range of the roosting birds in trees of moderate size. From any one place where the pole was pushed into the tree, several readings were usually possible, either at different altitudes, different places at the same altitude, or both. Then the pole was dismounted and the process repeated at another place in the tree. The sensitive disk was kept pointed to zenith as nearly as possible when a reading was taken. One person maneuvered the pole, and an assistant recorded the readings and helped to arrange the extensions.

The usual method was to set up the pole and to read zenith light in the open either 10 or 20 feet above the ground, depending on the size of the trees to be measured. Then the pole was assembled and disassembled

as needed to get 10 readings in each of two trees, and once more a reading was taken in the open. The process was repeated for two other trees, and sometimes for an additional two. After 10 readings had been secured in each of the four or six trees, the entire procedure was repeated, either once or twice. Thus either 20 or 30 readings were made in each tree during the evening; and outside readings were taken as often as every 10 to 12 minutes. Since the light was changing constantly, the average of the 10 readings in a tree was expressed as a percentage of the average light in the open during the same time, and an over-all average was computed for the evening.

Since the usual length of the pole was either 10 or 20 feet when it was inserted in the trees, the readings in the open were taken at a 10- or 20-foot elevation. This was largely a matter of convenience for no further time-consuming disassembly and reassembly were required. In addition, there was considerably less shading of the sensitive element from neighboring trees, and a broader cone of light was admitted.

A few trials revealed that the thin glass plate which protected the sensitive disk reduced the reading of the meter somewhat, but that on a percentage basis it made no difference for the degree of accuracy desired. The glass plate was cut from a discarded lantern slide with its emulsion removed.

Observing the Flights

To get an estimate of the total number of birds coming into Ames each evening, they were observed on their flight line on the last stage

of their flight for the day. Small groups were counted and larger groups were estimated by fives, 10's, or 100's. In 1949 the data were recorded as secured, but this proved cumbersome when huge flocks or extended flights flew by, for the observer had trouble in keeping tab of his numbers after they totalled in the thousands. The difficulty was overcome in 1950 when a simple hand tally counter was used. When the birds came at a rapid rate each estimate of 10 birds was recorded on the counter by a push of the thumb, and the results were recorded every 10 minutes or whenever a break occurred in the flight (Bliese, 1950). When the season advanced and the numbers of birds increased, each push on the counter represented 100 birds. Small flocks, on the other hand, were counted or estimated as in 1949, without the aid of the counter, and the numbers were recorded immediately as secured.

Only one counter made it impossible to keep track of the several species present in mixed flocks when the birds came at too rapid a rate. Therefore in 1951 and 1952 a multiple counter with four units was used, each of which was assigned to a different species. The multiple counter was constructed by the writer who used four ratchet-type rotation counters. The four units were mounted on a block of wood, and rubber bands were fastened to the lever arms and to the block in such a way as to serve as returning devices. Since there was no way to turn the counters to zero, they worked better for recording totals periodically than for keeping tab of individual flocks. Records were kept in the same way as when the single counter was used, but now the estimates of several species could be tallied when mixed flocks flew past the observer. Sometimes when only

the totals were wanted, all birds were tallied on the counter, and the readings were recorded at 10-minute intervals.

Not only were the birds counted, but in 1952 and 1952 records were kept of the weather conditions accompanying each flight. Wind velocity was measured with a Biram anemometer shortly before a flight began to arrive, and again after the flight was over. Temperature, relative humidity, and zenith light readings were taken every ten minutes. Temperatures were measured with a metal photographic thermometer that had been checked against mercury thermometers, and relative humidity readings were obtained from a Serdex Hygrometer, Model 201, that was guaranteed to be accurate within one and a half per cent. Light readings were obtained in the open with the Weston photometer previously described. The sensitive element was always supported on a wooden paddle equipped with two bubble levels at right angles to each other, with the aid of which it was pointed quickly to zenith. The light meter usually was supported on the end of an orange crate, while the hygrometer and thermometer were placed on a shorter box next to the orange crate so as always to be in its shade. Time was kept with a 17-jewel Swiss wrist watch that was always checked against radio time before going to the field.

RESULTS AND DISCUSSION

The Roost

Introductory remarks

Practically all the data that are presented in this thesis concerned the roost in northeast Ames. This section of the city, used extensively as a roost during all years of the present investigation, was studied intensively. Little is said about southwest Ames, which was used extensively only when the present study was strictly in its preliminary stages, and which thereafter ceased to attract many birds. Any city block was included in the tabulations if it had at least one tree used as a roost place, regardless of the degree of roosting it had received.

Because of space limitations a number of abbreviations are used in the tables throughout this thesis. These abbreviations, as well as several terms, are defined in the section "Definition of Terms and Abbreviations" on page 36.

Some of the data under "L" (light degree of roosting) in the tables undoubtedly contain records of trees that were more strictly stopping places rather than roost trees. Although it was usually possible to assign a tree to one category or the other, there was doubt in some cases. As far as people were concerned, it made little difference, for it was folly to park an automobile beneath either kind of tree, or to use the space beneath either for recreational purposes when the birds were there. In several instances direct observation of the birds

revealed that stopping places became roost trees, and vice versa. Everything considered, to have included some stopping places under "light roosting" did not introduce any grave errors.

Noticeable roosting in Ames began during the latter part of June and extended into the first part of November. While at first the roosting population was not very large, it rapidly increased, and by late July and early August literally thousands of birds were present.

Street trees versus back yard trees

Superficial examination had suggested early that few back yard trees were in use as places to roost. This impression had been strong enough that back yards were omitted entirely from critical observation in 1950, but in 1951 and 1952 the trees in the back yards of 40 city blocks were examined periodically. That the first impression was correct is shown in Tables 2 and 3, which summarize the observations for 1951 and 1952, respectively.

Table 2 shows that in 1951 roosting had occurred on 33 of the city blocks for which detailed maps and measurements had been made. The data are shown by degrees of use (none, light, moderate, heavy, which have been abbreviated N, L, M, H, respectively) as well as in a separate column merely indicating "use" (L&M&H, or the sum of the data under light, moderate, and heavy). Each tree had been tallied according to the highest degree of roosting to which it had been subjected during the year. Of the 436 trees located in the back yards only 31, or 7.0 per cent, were used for roosting purposes, as compared with 249, or 31.6 per cent, of the 788 trees along the streets. When the data are

Table 2. The degree of roosting according to location of trees on 33 city blocks, June 30 to October 25, 1951.

Location of trees	Total no. of trees	Number & per cent according to degree of use									
		Number					Per cent				
		N	L	M	H	L&M&H	N	L	M	H	L&M&H
Streets & yards	1224	944	126	100	54	280	77.1	10.3	8.2	4.5	22.9
Streets	788	539	104	92	53	249	68.4	13.2	11.7	6.7	31.6
Back yards	436	405	22	8	1	31	92.9	5.0	1.8	0.2	7.0

Table 3. The degree of roosting according to location of trees on 27 city blocks, June 24 to September 2, 1952.

Location of trees	Total no. of trees	Number & per cent according to degree of use									
		Number					Per cent				
		N	L	M	H	L&M&H	N	L	M	H	L&M&H
Streets & yards	1087	905	102	73	7	182	83.3	9.4	6.7	0.6	16.7
Streets	684	527	87	63	7	157	77.0	12.7	9.2	1.0	22.9
Back yards	403	378	15	10	0	25	93.8	3.7	2.5	0.0	6.2

contrasted by degrees of roosting use, the table shows that the birds used more street trees, both numerically and on a percentage basis, in each category.

Table 3 gives similar data for 1952. Although the individual statistics are somewhat different from those obtained in 1951, they are relatively comparable to them, and show the same general relationships. In both years the birds used a much smaller proportion of back yard trees than street trees. Some possible reasons for this are discussed in later sections.

That the data for street trees and for back yard trees in Table 3 did not represent samples from a common population was shown by two statistical tests of homogeneity. In one test the trees not used as roost places were contrasted with trees used, and in the second the N, L, M, and H data were compared. In both cases chi-square was over 50.00, with significance indicated far beyond the 1 per cent level. These tests, and all other statistical tests and procedures used for this investigation, followed the procedures outlined by Snedecor (1946). No tests were made for Table 2 in which the data are even more contrasting than in Table 3.

Use of trees by species

Annual summaries for street trees. Tables 4, 5, and 6, which include only the data for those blocks that were mapped and measured in detail, give the birds' use of trees for three years. Table 4, covering the period from August 2 to October 6, 1950, summarizes the data for 34 of the 120 city blocks on which the birds roosted at one time or another.

Table 4. Species of trees along the streets and the extent of their use as roost places on 34 city blocks, August 2 to October 6, 1950.

Species of trees	Total no. of trees	Number and per cent used according to degree of roosting									
		Number					Per cent				
		N	L	M	H	L&M&H	N	L	M	H	L&M&H
Elm, American	404	215	103	49	37	189	53.2	25.5	12.1	9.2	46.8
Maple, Black	139	43	43	26	27	96	30.9	30.9	18.7	19.4	69.0
Maple, Norway	45	25	8	6	6	20	55.6	17.8	13.3	13.3	44.4
Subtotals*	588	283	154	81	70	305	48.1	26.2	13.8	11.9	51.9
Ash, Green	25	23	1	1	0	2	92.0	4.0	4.0	0.0	8.0
Basswood	27	25	2	0	0	2	92.6	7.4	0.0	0.0	7.4
Box-Elder	12	9	2	0	1	3	75.0	16.7	0.0	8.3	25.0
Cottonwood	17	10	6	0	1	7	58.8	35.3	0.0	5.9	41.2
Hackberry	28	20	7	1	0	8	71.4	25.0	3.6	0.0	28.6
Maple, Silver	12	3	3	6	0	9	25.0	25.0	50.0	0.0	75.0
26 other species	95	90	5**	0	0	5	94.7	5.3	0.0	0.0	5.3
Subtotals*	216	180	26	8	2	36	83.3	12.0	3.7	0.9	16.6
Totals*	804	463	180	89	72	341	57.6	22.4	11.1	9.0	42.5

* The percentages in these rows have been computed directly from the numbers of the corresponding rows. (The same is true for all similar tables in this thesis.)

** Chinese elm--1; Slippery elm--1; Downy hawthorn--1; Tulip-tree--1; Black walnut--1.

Table 5. Species of trees along the streets and the extent of their use as roost places on 33 city blocks, June 30 to October 25, 1951.

Species of trees	Total no. of trees	Number and per cent used according to degree of roosting									
		Number					Per cent				
		N	L	M	H	L&M&H	N	L	M	H	L&M&H
Elm, American	399	257	60	48	34	142	64.4	15.0	12.0	8.5	35.5
Maple, Black	107	61	20	19	7	46	57.0	18.7	17.8	6.5	43.0
Maple, Norway	41	18	3	15	5	23	43.9	7.3	36.6	12.2	56.1
Subtotals	547	336	83	82	46	211	61.4	15.1	15.0	8.4	38.5
Ash, Green	20	18	1	1	0	2	90.0	5.0	5.0	0.0	10.0
Box-Elder	15	13	1	1	0	2	86.7	6.7	6.7	0.0	13.4
Catalpa, Common	5	3	2	0	0	2	60.0	40.0	0.0	0.0	40.0
Cottonwood	20	6	3	6	5	14	30.0	15.0	30.0	25.0	70.0
Elm, Chinese	11	8	1	1	1	3	72.7	9.1	9.1	9.1	27.3
Hackberry	18	12	4	1	1	6	66.7	22.2	5.6	5.6	33.4
Maple, Silver	10	6	4	0	0	4	60.0	40.0	0.0	0.0	40.0
44 other species	142	137	5*	0	0	5	96.5	3.5	0.0	0.0	3.5
Subtotals	241	203	21	10	7	38	84.2	8.7	4.1	2.9	15.7
Totals	788	539	104	92	53	249	68.4	13.2	11.7	6.7	31.6

* Basswood—1; Paper birch—1; Slippery elm—1; Russian olive—1; Sycamore—1.

Table 6. Species of trees along the streets and the extent of their use as roost places on 27 city blocks, June 24 to September 2, 1952.

Species of trees	Total no. of trees	Number and per cent used according to degree of roosting									
		Number					Per cent				
		N	L	M	H	L&M&H	N	L	M	H	L&M&H
Elm, American	326	260	44	21	1	66	79.8	13.5	6.4	0.3	20.2
Maple, Black	119	55	25	33	6	64	46.2	21.0	27.7	5.1	53.8
Maple, Norway	41	23	12	6	0	18	56.1	29.3	14.6	0.0	43.9
Subtotals	486	338	81	60	7	148	69.5	16.7	12.3	1.4	30.4
Box-Elder	13	12	1	0	0	1	92.3	7.7	0.0	0.0	7.7
Cottonwood	8	5	1	2	0	3	62.5	12.5	25.0	0.0	37.5
Maple, Silver	13	10	3	0	0	3	76.9	23.1	0.0	0.0	23.1
44 other species	164	162	1*	1**	0	2	98.8	0.6	0.6	0.0	1.2
Subtotals	198	189	6	3	0	9	95.5	3.0	1.5	0.0	4.5
Totals	684	527	87	63	7	157	77.0	12.7	9.2	1.0	22.9

* Green ash.

** Chinese elm.

Table 5 gives the summary for 33 of the 64 city blocks used as roost in 1951. These data are particularly complete because they include the entire season, from June 30 to October 25. In a similar way Table 6, for the period extending from June 24 to September 2, 1952, shows the birds' use of trees on 27 of the 40 city blocks used as roost sites.

As shown by the above-mentioned tables, roosting during the three years, 1950 to 1952, was largely a phenomenon of American elms and hard maples (black and Norway). Only in 1952 were less than 20 trees of any of the three species in the American elm-hard maple group used as roost places. In that year the number for Norway maples fell to 18. Of all the other species of trees, the cottonwoods alone, in 1951, approached the 20 mark with a count of 14 roost trees. On a percentage basis over one half, 51.9 per cent, of these species were used as roost trees in 1950 as compared with 16.6 per cent for all other species combined. In 1951 the corresponding data were 38.5 per cent and 15.7 per cent, and in 1952 they were 30.4 per cent and 4.5 per cent, respectively. The downhill trend noted for analogous data seemed to be a reflection of an apparently decreasing bird population during the three years. When the data for the two major groups of trees shown in the tables are compared according to degree of use, it can be seen that the birds roosted in a greater number and percentage of the American elms and hard maples in each category during all three years.

Examined by species rather than by groups of species, Tables 4, 5, and 6 show that the birds used more American elms than other species numerically, but that on a percentage basis the situation in general was different. With the exception of 1950, when a larger percentage of

American elms than of Norway maples was used as roost trees by the birds, the percentages for either of the hard maples were considerably higher than those for the American elms.

The same tables also indicate that the two species of hard maples received differential use. In both 1950 and 1952 a greater percentage of black maples than of Norway maples was used, but in 1951 the reverse was true. Thus there were two reversals in proportionate roosting while the population of birds was on the decrease, between 1950 and 1951 and between 1951 and 1952. Since the percentages for the trees according to degree of use did not follow the same pattern, the differences in the percentages noted were probably of no significance. The numbers of Norway maples used during the three years varied by only five trees. The birds' needs were met equally well by both species and they used the one that happened to be present at the particular site where they roosted.

Two statistical tests of homogeneity also indicated that the birds used the American elms and hard maples differentially. The data for 1951 (Table 5) were used in the analysis because they alone concerned an entire roosting season. In the first test the three species were contrasted according to use and non-use, and in the second test the L, M, and H columns were compared. In each case chi-square was significant at less than 5 per cent.

Several other species of trees were used as roost places in rather high percentages. These trees, listed in the lower groups in Tables 4, 5, and 6 included: green ash, box-elder, cottonwood, hackberry, and

silver maple. Though present in small numbers, observations indicated that the birds used a sizeable proportion of these trees in at least two of the three years. Cottonwoods and silver maples, in fact, showed considerable percentage of use for all three years. Apparently the birds found these species quite satisfactory and used them when they happened to be located at the roosting sites. That this was true for the several degrees of use, as well as for "use", is indicated in the tables.

Annual summaries for back yard trees. Data for back yard trees, collected in the two years, 1951 and 1952, are shown in Tables 7 and 8. In 1951 (Table 7) only 10 trees, or 7.2 per cent of the American elm-hard maple group were occupied by the birds as roost trees, and only 21 trees, or 7.1 per cent of all other species combined were used. For 1952 (Table 8) the corresponding data were 17 trees, or 12.8 per cent, and eight trees, or 2.9 per cent, respectively. Furthermore, roosting in the two groups of trees according to degree of use was quite in agreement with the totals. In other words, back yard roosting was not an American elm-hard maple phenomenon in 1951, but was such in 1952.

In both 1951 and 1952 a smaller percentage of American elms than of hard maples was used by the birds (Tables 7 and 8). Though there were few hard maples available, the birds' use thereof gave the same general picture as for the street tree data (Tables 4 to 6), except for their near absence in the M and H columns. When the N columns and the I&M&H columns for the American elms and hard maples were compared by tests of homogeneity, chi-square for the 1951 data in Table 7 showed up as non-significant, probably because only one hard maple was represented as a roost tree. The 1952 data (Table 8), however, tested significant at the

Table 7. Back yard trees and the extent of their use as roost places on 33 city blocks, June 30 to October 25, 1951.

Species of trees	Total no. of trees	Number and per cent used according to degree of roosting									
		Number					Per cent				
		N	L	M	H	L&M&H	N	L	M	H	L&M&H
Elm, American	126	117	6	3	0	9	92.9	4.8	2.4	0.0	7.2
Maple, Black	7	7	0	0	0	0	100.0	0.0	0.0	0.0	0.0
Maple, Norway	6	5	1	0	0	1	83.3	16.7	0.0	0.0	16.7
Subtotals	139	129	7	3	0	10	92.8	5.0	2.2	0.0	7.2
Box-Elder	25	18	3	3	1	7	72.0	12.0	12.0	4.0	28.0
Catalpa, Common	4	2	2	0	0	2	50.0	50.0	0.0	0.0	50.0
Cottonwood	9	6	3	0	0	3	66.7	33.3	0.0	0.0	33.3
Elm, Chinese	3	2	1	0	0	1	66.7	33.3	0.0	0.0	33.3
Hackberry	14	13	1	0	0	1	92.9	7.1	0.0	0.0	7.1
Maple, Silver	5	3	2	0	0	2	60.0	40.0	0.0	0.0	40.0
Walnut, Black	24	22	2	0	0	2	91.7	8.3	0.0	0.0	8.3
32 other species	213	210	1*	2**	0	3	98.6	0.5	0.9	0.0	1.4
Subtotals	297	276	15	5	1	21	92.9	5.1	1.7	0.3	7.1
Totals	436	405	22	8	1	31	92.9	5.0	1.8	0.2	7.0

* Common apple.

** Buttermut--1; White mulberry--1.

Table 8. Back yard trees and the extent of their use as roost places on 27 city blocks, June 24 to September 2, 1952.

Species of trees	Total no. of trees	Number and per cent used according to degree of roosting									
		Number					Per cent				
		N	L	M	H	L&M&H	N	L	M	H	L&M&H
Elm, American	119	108	6	5	0	11	90.8	5.0	4.2	0.0	9.2
Maple, Black	7	3	2	2	0	4	42.9	28.6	28.6	0.0	57.2
Maple, Norway	7	5	2	0	0	2	71.4	28.6	0.0	0.0	28.6
Subtotals	133	116	10	7	0	17	87.2	7.5	5.3	0.0	12.8
Box-Elder	21	15	3	3	0	6	71.4	14.3	14.3	0.0	28.6
Elm, Siberian	4	2	2	0	0	2	50.0	50.0	0.0	0.0	50.0
35 other species	245	245	0	0	0	0	100.0	0.0	0.0	0.0	0.0
Subtotals	270	262	5	3	0	8	97.0	1.8	1.1	0.0	2.9
Totals	403	378	15	10	0	25	93.8	3.7	2.5	0.0	6.2

1 per cent level, and thus indicated the same phenomenon noted for street trees.

The data for the species in the lower group of trees in Table 7, though based on very few trees for some species, also strengthen the conclusion already reached from street-tree data that box-elders, cottonwoods, hackberries, and silver maples, and perhaps one or two other species of trees, were satisfactory roost places for the birds. In 1952, on the other hand, the above-mentioned species, with the exception of the box-elders and Siberian elms, received no attention from the birds. This may have been caused by the smaller populations of birds, which used only the sites along the streets, or by the lack of any data for the late fall.

Changes with the season. One of the reasons for making periodic checks of the study areas was to discover what seasonal changes, if any, occurred in the use of the several species of trees. The question had been raised, for instance, whether the birds' use of the American elms, hard maples, and other species, remained relatively the same from June to November, or whether there were noticeable differences as time went on.

The pertinent data for American elms, black maples, Norway maples, and all other species combined are given in Tables 9 to 12. Although the data for 1950 and 1952 do not extend over as many months as those for 1951, there is enough overlapping for conclusions to be reached. Since the back yard trees were of little consequence to the birds, and since those that were used were too few in number to warrant any positive conclusions, only street data are included. The percentages of trees used as roost places are shown graphically in Figure 2.

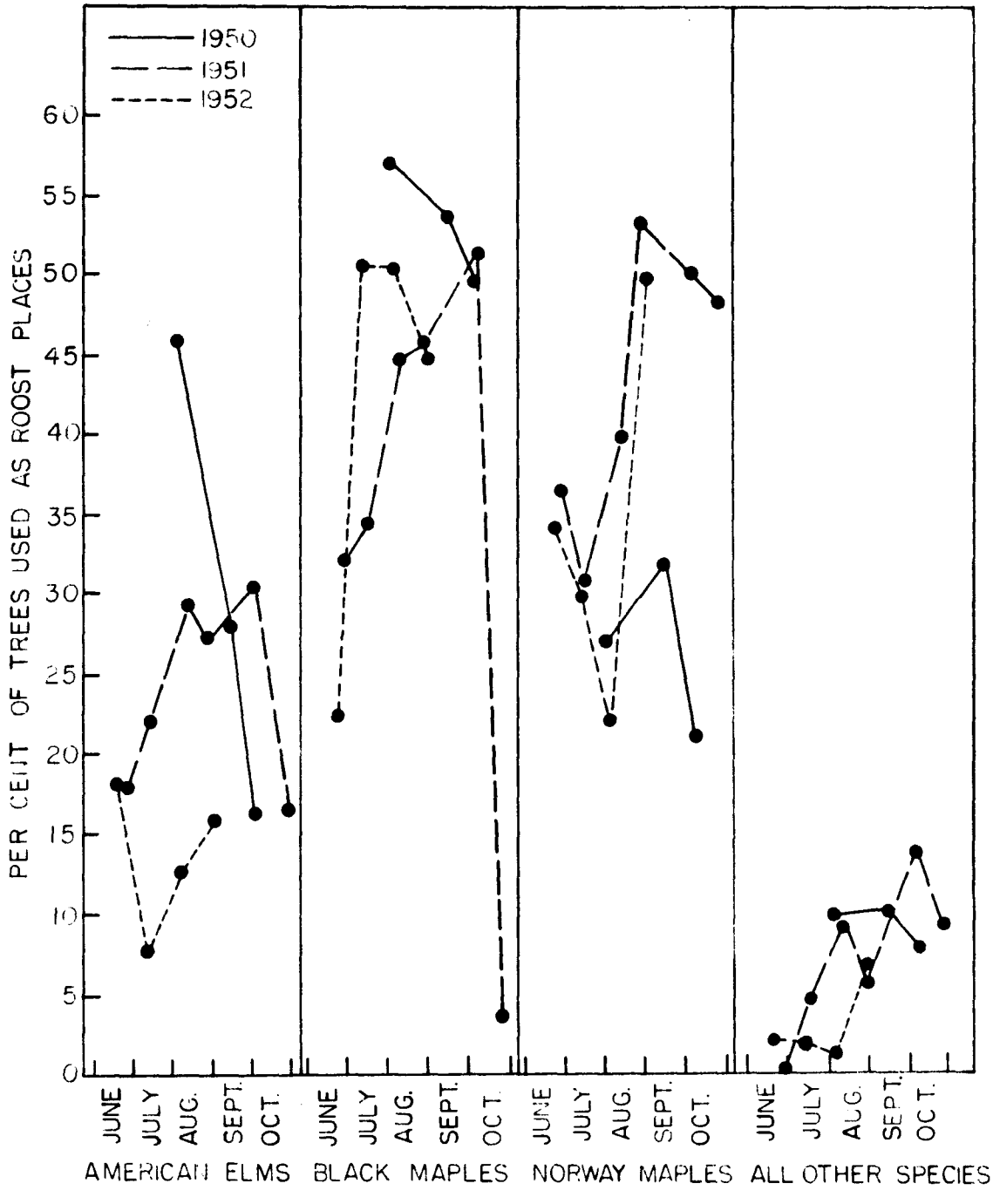


Figure 2. Per cent of street trees used as roost places with the advancing season.

As far as the American elms are concerned (Table 9), there was little similarity among the observations for the three years. Not only were the figures for any one year different from those secured at corresponding times in another year, both numerically and also on a percentage basis, but the changes from one month to another were as often in opposite directions as they were in the same directions.

The many birds that left the northeast Ames area to roost for a while in southwest Ames may have been responsible for the sharp decline noted in percentage of use between August 2 and September 14 in 1950 (Table 9). The continued decline for that year probably was caused by the early migration of many of the birds, or at least the non-return to Ames, after strong winds near the end of September had considerably reduced the foliage on the trees. The sharp drop in percentage of use between June 24 and July 11, 1952, was seemingly related to a change in sites by the birds when they moved from Clark Avenue to Duff Avenue. This change had also been made in 1950, but not until later in the year after the bird population had increased considerably. Duff Avenue was largely a black maple site but Clark Avenue had a greater proportion of American elms. The sharp decline for the October, 1951 data was apparently caused by migration. With the above exceptions, the only seasonal change noted for American elms was a general increase in percentage of use, which was explainable on the basis of increases in bird population. No other seasonal change in the birds' use of American elms was obvious from the data nor needed postulation.

The trends for black maples (Table 10) in a very general way paralleled those for American elms. The one exception, the sharp increase

Table 9. American elms along the streets and the extent of their use as roost places with the advancing season.

Date	No. of blocks	No. of trees	No. & % according to degree of use				
			N	L	M	H	L&M&H
1950							
Aug. 2	17	183	99*	60	6	18	84
			54.1**	32.8	3.3	9.8	45.9
Sept. 14	25	309	223	40	36	10	86
			72.2	12.9	11.7	3.2	27.8
Oct. 6	27	337	281	29	22	5	56
			83.4	8.6	6.5	1.5	16.6
1951							
June 30	14	159	131	17	9	2	28
			82.4	10.7	5.7	1.3	17.7
July 16	19	227	177	25	21	4	50
			77.9	11.0	9.3	1.8	22.1
Aug. 11	23	271	194	38	27	12	77
			71.6	14.0	10.0	4.4	28.4
Aug. 30	19	220	161	36	20	3	59
			73.2	16.4	9.1	1.4	26.9
Oct. 5	13	146	101	18	19	8	45
			69.2	12.3	13.0	5.5	30.8
Oct. 25	19	234	195	28	6	5	39
			83.3	12.0	2.6	2.1	16.7
1952							
June 24	13	212	173	28	11	0	39
			81.6	13.2	5.2	0.0	18.4
July 11	13	156	144	8	4	0	12
			92.3	5.1	2.6	0.0	7.7
Aug. 6	12	144	126	12	6	0	18
			87.5	8.3	4.2	0.0	12.5
Sept. 2	11	120	101	11	7	1	19
			84.2	9.2	5.8	0.8	15.8

*Number
**Per cent

Table 10. Black maples along the streets and the extent of their use as roost places with the advancing season.

Date	No. of blocks	No. of trees	No. & % according to degree of use				
			N	L	M	H	L&M&H
1950							
Aug. 2	17	58	25 43.1	15 25.9	9 15.5	9 15.5	33 56.9
Sept. 14	25	123	57 46.3	40 32.5	16 13.0	10 8.1	66 53.6
Oct. 6	27	127	64 50.4	33 26.0	18 14.2	12 9.4	63 49.6
1951							
June 30	14	50	34 68.0	10 20.0	6 12.0	0 0.0	16 32.0
July 16	19	64	42 65.7	12 18.8	8 12.5	2 3.1	22 34.4
Aug. 11	23	71	39 54.9	15 21.1	13 18.3	4 5.6	32 45.0
Aug. 30	19	66	36 54.5	19 28.8	11 16.8	0 0.0	30 45.6
Oct. 5	13	39	19 48.7	11 28.2	6 15.4	3 7.7	20 51.3
Oct. 25	19	52	50 96.2	2 3.8	0 0.0	0 0.0	2 3.8
1952							
June 24	13	49	38 77.6	7 14.3	4 8.2	0 0.0	11 22.5
July 11	13	75	37 49.3	19 25.3	19 25.3	0 0.0	38 50.6
Aug. 6	12	85	42 49.4	18 21.2	21 24.7	4 4.7	43 50.6
Sept. 2	11	85	47 55.3	21 24.7	13 15.3	4 4.7	38 44.7

in percentage between June 24 and July 11 in the data for 1952, was to be expected on the basis of the shift in roost sites from Clark Avenue to Duff Avenue, already explained in the discussion for American elms. Again there was no basis for postulating a change in the birds' use of roost trees with the advancing season other than that which was a consequence of more birds coming to Ames each night as the season advanced.

Observations on the Norway maples, summarized in Table 11, also did not show conclusively any seasonal change in the birds' use of the trees other than those already explained. In general there was an increase in the proportion of trees used as the season advanced and the bird population increased, but the trends from mid-July to mid-August in 1951 were opposite to those in 1952. The rather gradual drop in per cent of use toward the end of 1951, as compared with the sharper drops for American elms and black maples, was probably the result of the longer retention of leaves. Many Norway maples still had an abundance of cover at a time when American elms, and especially black maples, were practically bare.

The birds apparently responded to all trees other than American elms and hard maples in the same general way as they did toward the elms and maples. There was no evidence, as Table 12 shows, that there were any changes other than those explainable on the basis of an increasing bird population.

Whether the trees were merely checked for use, or whether they were observed for degree of use, the conclusions were the same, and Tables 9 to 12 show that there was no consistent repetition of trends from one year to the next. With a few exceptions, if there was an increase in the use of trees for light roosting, there were comparable increases for

Table 11. Norway maples along the streets and the extent of their use as roost places with the advancing season.

Date	No. of blocks	No. of trees	No. & % according to degree of use				
			N	L	M	H	L&M&H
1950							
Aug. 2	17	26	19 73.1	3 11.5	1 3.8	3 11.5	7 26.8
Sept. 14	25	25	17 68.0	6 24.0	2 8.0	0 0.0	8 32.0
Oct. 6	27	38	30 78.9	4 10.5	4 10.5	0 0.0	8 21.0
1951							
June 30	14	30	19 63.3	4 13.3	6 20.0	1 3.3	11 36.6
July 16	19	26	18 69.2	1 3.8	5 19.2	2 7.7	8 30.7
Aug. 11	23	37	26 70.3	8 21.6	1 2.7	2 5.4	11 39.7
Aug. 30	19	30	14 46.7	5 16.7	10 33.3	1 3.3	16 53.3
Oct. 5	13	22	11 50.0	4 18.2	4 18.2	3 13.6	11 50.0
Oct. 25	19	29	15 51.7	4 13.8	7 24.1	3 10.3	14 48.2
1952							
June 24	13	35	23 65.7	10 28.6	2 5.7	0 0.0	12 34.3
July 11	13	20	14 70.0	5 25.0	1 5.0	0 0.0	6 30.0
Aug. 6	12	18	14 77.8	4 22.2	0 0.0	0 0.0	4 22.2
Sept. 2	11	16	8 50.0	4 25.0	4 25.0	0 0.0	8 50.0

Table 12. All trees along the streets, other than American elms and hard maples, and the extent of their use as roost places with the advancing season.

Date	No. of blocks	No. of trees	No. & % according to degree of use				
			N	L	M	H	L&M&H
1950							
Aug. 2	17	111	100	10	0	1	11
			90.1	9.0	0.0	0.9	9.9
Sept. 14	25	136	122	10	4	0	14
			89.7	7.4	2.9	0.0	10.3
Oct. 6	27	182	168	13	1	0	14
			92.3	7.1	0.5	0.0	7.6
1951							
June 30	14	131	131	0	0	0	0
			100.0	0.0	0.0	0.0	0.0
July 16	19	158	151	5	2	0	7
			95.6	3.2	1.3	0.0	4.5
Aug. 11	23	180	163	12	4	1	17
			90.6	6.7	2.2	0.6	9.5
Aug. 30	10	155	146	5	3	1	9
			94.2	3.2	1.9	0.6	5.7
Oct. 5	13	137	118	16	3	0	19
			86.1	11.7	2.2	0.0	13.9
Oct. 25	19	171	155	7	5	4	16
			90.6	4.1	2.9	2.3	9.3
1952							
June 24	13	148	145	1	2	0	3
			98.0	0.7	1.3	0.0	2.0
July 11	13	111	109	1	1	0	2
			98.2	0.9	0.9	0.8	1.8
Aug. 6	12	99	98	1	0	0	1
			99.0	1.0	0.0	0.0	1.0
Sept. 2	11	78	73	5	0	0	5
			93.6	6.4	0.0	0.0	6.4

moderate roosting and heavy roosting, and the same relationship existed for decreases. The most obvious exceptions occurred in the 1951 data for Norway maples (Table 11). Here a decrease in one degree of roosting was as often accompanied by an increase as by a decrease in the other two degrees of roosting. Since this erratic behavior did not show up in the other two years, it probably had no particular significance.

One aspect of the seasonal changes in use of species of trees did not appear from the results of the periodic tours. Many observations, early in June, disclosed that thousands of birds were roosting in conifer trees in the western part of the college arboretum, and in similar groves elsewhere, and hundreds of birds repeatedly were seen to leave Ames and fly toward such spring roosts. Nevertheless, by the first week in June, before any flight lines led into the city, small groups of a dozen or two bronzed grackles were already roosting in scattered localities in the northeast Ames study area. No detailed tours of the study area were made at that time, but casual observation revealed several of these roost nuclei. All of those seen involved black maples, and only one to two trees at a place were ever noted to be in use. At several of these places, among them the 700-block on Carroll Avenue, the 1100-block on Wilson Avenue, and the 1100-block on Douglas Avenue, the birds later developed extensive roost sites.

Thus, at least two seasonal changes in the use of species of trees occurred during the month of June. First, the birds began to leave the conifer groves in the country and to come to the deciduous trees in the city, and, second, they began to use American elms and other species of trees in addition to black maples.

Use of trees by size

General considerations. Since it was obvious from the very beginning of the investigation that the birds did not roost in the smaller trees, efforts were made to find out what size they did use. Because consultation with an ecologist and a forester, as well as reading in the literature, revealed no one measurement that would serve as an ideal index of the sizes of the trees for purposes of the present study, it was decided to try two measurements per tree: the diameter of the trunk at breast height in inches, (or DBH as it is frequently called hereafter), and the height of the tree in feet.

Although the trunk diameters were readily secured with a Biltmore stick, the heights were another problem even with the simple hypsometer method. To measure the height of a tree the top or highest point had to be visible. While such points were easily sighted on such trees as the hard maples, the shape of the crowns of American elms and some other species often made this almost impossible. To guard against errors, the measurements secured for a tree were always compared with those of the trees immediately adjacent, and trees that caused any difficulty were measured from several positions in addition.

Several days spent in measuring trees convinced the writer that the height of a tree, while important enough by itself, did not give a complete picture of the tree as a prospective roost place. Two trees of identical height, even if they were of the same species, often had very different quantities of crown and were frequently of different shape and had different amounts of cover. At some sites the birds used the taller

trees only as stopping places, if at all, and then roosted in nearby shorter trees.

To see what relationship existed between the DBH's and the heights of the trees, coefficients of correlation were computed and are shown in Table 13. To get data for these coefficients the measurements for the trees on the 33 city blocks, that had been roost sites in 1951, were used.

Table 13. Coefficients of correlation between the DBH's and the heights of trees on 33 city blocks in northeast Ames.

Species of trees	Number of trees used in the computation	Coefficient of correlation (r)
Elm, American	249	.8749
Maple, Black	113	.8346
Maple, Norway	47	.8598
American elms and hard maples combined	409	.8838
All trees other than American elms and hard maples	319	.8463

Since there were relatively few black maples on the 33 city blocks, all were used in the computations. However, it was deemed that there were more than enough American elms and other species present to determine the coefficients, and only those which had been assigned odd numbers on the detailed maps were so used. The decision to use the odd numbered ones was made by flipping a coin.

Table 13 indicates that high correlations existed between the DBH's

and the heights of the trees in the study areas, whether we were dealing with the several species of trees individually or whether we were considering several combinations of species. On the basis of this table and on the considerations previously discussed, it was decided that the height of a tree was probably no better as an index of the size of a tree than the more easily obtained DBH. Data presented in the sections immediately following have consequently been based on the DBH measurements.

Annual summaries for street trees. Tables 14, 15, and 16 show the extent of roosting that occurred in American elms along the streets during 1950, 1951, and 1952, respectively, according to their diameters at breast height. As has been indicated in the L&M&H columns in the three tables, a wide range of tree sizes were used by the birds, but no trees less than seven to eight inches DBH served as roost places. In general, an increase in tree size was accompanied by a greater proportion of use in all three years, but this tendency was more erratic in 1951 and 1952 when the bird population was on the decrease.

Though they were present in low numbers, some of the largest trees were observed to have been used as roost places in very high percentages. Since these high proportions occurred in three successive years, and seemed to be the culmination of the general trend of larger percentages for larger trees, it was concluded that the birds apparently tended to use such large trees if they were available at the roost site.

Whether the birds used the trees lightly, moderately, or heavily, they tended to use a larger proportion of the larger trees. As is shown in the L, M, and H columns in Tables 14 to 16, the tendency was very irregular, however, based as it was in fewer trees in each category

Table 14. Diameters at breast height of American elms along the streets and the extent of their use as roost trees on 34 city blocks, August 2 to October 6, 1950.

DBH	No. of trees	Number & per cent according to degree of use									
		Number					Per cent				
		N	L	M	H	L&M&H	N	L	M	H	L&M&H
1- 2	7	7	0	0	0	0	100.0	0.0	0.0	0.0	0.0
3- 4	13	13	0	0	0	0	100.0	0.0	0.0	0.0	0.0
5- 6	4	4	0	0	0	0	100.0	0.0	0.0	0.0	0.0
7- 8	14	11	2	0	1	3	78.6	14.3	0.0	7.1	21.4
9-10	19	17	2	0	0	2	89.5	10.5	0.0	0.0	10.5
11-12	34	27	7	0	0	7	79.4	20.6	0.0	0.0	20.6
13-14	38	28	6	3	1	10	73.7	15.8	7.9	2.6	26.3
15-16	21	12	6	1	2	9	57.1	28.6	4.8	9.5	42.9
17-18	36	20	10	2	4	16	55.6	27.8	5.6	11.1	44.5
19-20	30	15	6	4	5	15	50.0	20.0	13.3	16.7	50.0
21-22	35	14	13	5	3	21	40.0	37.1	14.3	8.6	60.0
23-24	34	15	9	7	3	19	44.1	26.5	20.6	8.8	55.9
25-26	36	9	12	8	7	27	25.0	33.3	22.2	19.4	74.9
27-28	31	12	9	4	6	19	38.7	29.0	12.9	19.4	60.3
29-30	20	8	9	2	1	12	40.0	45.0	10.0	5.0	60.0
31-32	11	1	6	4	0	10	9.1	54.6	36.4	0.0	91.0
33-34	7	1	3	2	1	6	14.3	42.9	28.6	14.3	85.8
35-36	7	1	2	3	1	6	14.3	28.6	42.9	14.3	85.8
37-38	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
39-40	3	0	0	2	1	3	0.0	0.0	66.7	33.3	100.0
41-42	3	0	1	2	0	3	0.0	33.3	66.7	0.0	100.0
43-44	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
45-46	1	0	0	0	1	1	0.0	0.0	0.0	100.0	100.0
Totals	404	215	103	49	37	189	53.2	25.5	12.1	9.2	46.8

Table 15. Diameters at breast height of American elms along the streets and the extent of their use as roost trees on 33 city blocks, June 30 to October 25, 1951.

DBH	No. of trees	Number & per cent according to degree of use									
		Number					Per cent				
		N	L	M	H	L&M&H	N	L	M	H	L&M&H
1- 2	8	8	0	0	0	0	100.0	0.0	0.0	0.0	0.0
3- 4	17	17	0	0	0	0	100.0	0.0	0.0	0.0	0.0
5- 6	9	9	0	0	0	0	100.0	0.0	0.0	0.0	0.0
7- 8	20	18	2	0	0	2	90.0	10.0	0.0	0.0	10.0
9-10	22	21	1	0	0	1	95.5	4.5	0.0	0.0	4.5
11-12	19	17	1	1	0	2	89.5	5.3	5.3	0.0	10.6
13-14	37	30	4	2	1	7	81.1	10.8	5.4	2.7	18.9
15-16	22	14	3	5	0	8	63.6	13.6	22.7	0.0	36.3
17-18	34	22	4	5	3	12	64.7	11.8	14.7	8.8	35.3
19-20	34	20	5	5	4	14	58.8	14.7	14.7	11.8	41.2
21-22	27	12	5	4	6	15	44.4	18.5	14.8	22.2	55.5
23-24	44	24	9	6	5	20	54.5	20.5	13.6	11.4	45.5
25-26	31	12	4	9	6	19	38.7	12.9	29.0	19.4	61.3
27-28	31	12	8	7	4	19	38.7	25.8	22.6	12.9	61.3
29-30	22	13	6	1	2	9	59.1	27.3	4.5	9.1	40.9
31-32	8	4	3	0	1	4	50.0	37.5	0.0	12.5	50.0
33-34	5	3	0	1	1	2	60.0	0.0	20.0	20.0	40.0
35-36	3	1	1	1	0	2	33.3	33.3	33.3	0.0	66.6
37-38	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
39-40	2	0	1	1	0	2	0.0	50.0	50.0	0.0	100.0
41-42	2	0	2	0	0	2	0.0	100.0	0.0	0.0	100.0
43-44	1	0	0	0	1	1	0.0	0.0	0.0	100.0	100.0
45-46	1	0	1	0	0	1	0.0	100.0	0.0	0.0	100.0
Totals	399	257	60	48	34	142	64.4	15.0	12.0	8.5	35.5

Table 16. Diameters at breast height of American elms along the streets and the extent of their use as roost trees on 27 city blocks, June 24 to September 2, 1952.

DBH	No. of trees	Number & per cent according to degree of use									
		Number					Per cent				
		N	L	M	H	L&M&H	N	L	M	H	L&M&H
1- 2	8	8	0	0	0	0	100.0	0.0	0.0	0.0	0.0
3- 4	15	15	0	0	0	0	100.0	0.0	0.0	0.0	0.0
5- 6	5	5	0	0	0	0	100.0	0.0	0.0	0.0	0.0
7- 8	16	16	0	0	0	0	100.0	0.0	0.0	0.0	0.0
9-10	15	14	1	0	0	1	93.3	6.7	0.0	0.0	6.7
11-12	27	27	0	0	0	0	100.0	0.0	0.0	0.0	0.0
13-14	29	28	1	0	0	1	96.6	3.4	0.0	0.0	3.4
15-16	19	19	0	0	0	0	100.0	0.0	0.0	0.0	0.0
17-18	18	16	0	2	0	2	88.9	0.0	22.2	0.0	22.2
19-20	24	16	4	4	0	8	66.7	16.7	16.7	0.0	33.4
21-22	21	17	2	2	0	4	81.0	9.5	9.5	0.0	19.0
23-24	32	15	10	7	0	17	46.9	31.3	21.9	0.0	53.2
25-26	28	18	8	2	0	10	64.3	28.6	7.1	0.0	35.7
27-28	25	18	3	3	1	7	72.0	12.0	12.0	4.0	28.0
29-30	19	14	5	0	0	5	73.7	26.3	0.0	0.0	26.3
31-32	8	5	2	1	0	3	62.5	25.0	12.5	0.0	37.5
33-34	5	3	2	0	0	2	60.0	40.0	0.0	0.0	40.0
35-36	6	5	1	0	0	1	83.3	16.7	0.0	0.0	16.7
37-38	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
39-40	3	1	2	0	0	2	33.3	66.7	0.0	0.0	66.7
41-42	2	0	2	0	0	2	0.0	100.0	0.0	0.0	100.0
43-44	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
45-46	1	0	1	0	0	1	0.0	100.0	0.0	0.0	100.0
Totals	326	260	44	21	1	66	79.8	13.5	6.4	0.3	20.2

than were available for tabulation in the L&M&H columns. It was the most erratic for the heavily used trees where the fewest trees were represented, and was more irregular during 1952 (Table 16) than for the other two years, apparently for the same reason.

With the exception of a seven-inch American elm, recorded as receiving heavy roosting in 1950 (Table 14), the smaller trees were used lightly if at all. The exceptional tree was near a larger elm which was heavily used by the birds and was partly overtopped by it. The crowns of the two trees were continuous.

Data comparable to that just discussed for American elms is given for black maples in Tables 17, 18, and 19. As shown by the L&M&H columns, the tendency for increasing size to be accompanied by increasing percentage of use was strongly marked for 1950, not evident in 1951, and irregularly present in 1952. As was true for American elms, the irregularity was associated with a smaller number of the trees, and the absence of the tendency was associated with a still smaller number. The observations, in other words, were probably too few in the several size categories in 1951 to reach any definite conclusions. When the data are examined by degree of use, the tables show that the same general tendency was present for moderately used trees and the heavily used trees in 1950 and 1952. In 1951, with fewer trees represented, the trend was irregular and inconclusive. For the lightly used black maples, on the other hand, a tendency was found to exist which was not seen for American elms. In all three years there was a general decrease in the percentage of use with increase in size of these trees.

By and large, therefore, the birds evidently used the larger black

Table 17. Diameters at breast height of black maples along the streets and the extent of their use as roost trees on 34 city blocks, August 2 to October 6, 1950.

DBH	No. of trees	Number & per cent according to degree of use									
		Number					Per cent				
		N	L	M	H	I&M&H	N	L	M	H	I&M&H
1- 2	4	4	0	0	0	0	100.0	0.0	0.0	0.0	0.0
3- 4	4	4	0	0	0	0	100.0	0.0	0.0	0.0	0.0
5- 6	7	7	0	0	0	0	100.0	0.0	0.0	0.0	0.0
7- 8	4	2	2	0	0	2	50.0	50.0	0.0	0.0	50.0
9-10	3	1	2	0	0	2	33.3	66.7	0.0	0.0	66.7
11-12	7	2	3	1	1	5	28.6	42.9	14.3	14.3	71.5
13-14	13	8	4	0	1	5	61.5	30.8	0.0	7.7	38.5
15-16	28	8	10	6	4	20	28.6	35.7	21.4	14.3	71.4
17-18	27	4	10	6	7	23	14.8	37.0	22.2	25.9	85.1
19-20	16	1	7	3	5	15	6.3	43.8	18.8	31.3	93.9
21-22	19	2	4	7	6	17	10.5	21.1	36.8	31.6	89.5
23-24	5	0	1	2	2	5	0.0	20.0	40.0	40.0	100.0
25-26	1	0	0	1	0	1	0.0	0.0	100.0	0.0	100.0
27-28	1	0	0	0	1	1	0.0	0.0	0.0	100.0	100.0
Totals	139	43	43	26	27	96	30.9	30.9	18.7	19.4	69.0

Table 18. Diameters at breast height of black maples along the streets and the extent of their use as roost trees on 33 city blocks, June 30 to October 25, 1951.

DBH	No. of trees	Number & per cent according to degree of use									
		Number					Per cent				
		N	L	M	H	I&M&H	N	L	M	H	I&M&H
1- 2	4	4	0	0	0	0	100.0	0.0	0.0	0.0	0.0
3- 4	4	4	0	0	0	0	100.0	0.0	0.0	0.0	0.0
5- 6	5	5	0	0	0	0	100.0	0.0	0.0	0.0	0.0
7- 8	3	3	0	0	0	0	100.0	0.0	0.0	0.0	0.0
9-10	4	1	2	1	0	3	25.0	50.0	25.0	0.0	75.0
11-12	8	3	4	1	0	5	37.5	50.0	12.5	0.0	62.5
13-14	12	9	1	2	0	3	75.0	8.3	16.7	0.0	25.0
15-16	24	8	6	8	2	16	33.3	25.0	33.3	8.3	66.6
17-18	20	11	4	4	1	9	55.0	20.0	20.0	5.0	45.0
19-20	10	4	1	3	2	6	40.0	10.0	30.0	20.0	60.0
21-22	11	7	3	0	2	4	63.6	18.2	0.0	18.2	36.4
23-24	2	2	0	0	0	0	100.0	0.0	0.0	0.0	0.0
Totals	107	61	20	19	7	46	57.0	18.7	17.8	6.5	43.0

Table 19. Diameters at breast height of black maples along the streets and the extent of their use as roost trees on 27 city blocks, June 24 to September 2, 1952.

DBH	No. of trees	Number & per cent according to degree of use									
		Number					Per cent				
		N	L	M	H	L&M&H	N	L	M	H	L&M&H
1- 2	4	4	0	0	0	0	100.0	0.0	0.0	0.0	0.0
3- 4	2	2	0	0	0	0	100.0	0.0	0.0	0.0	0.0
5- 6	8	8	0	0	0	0	100.0	0.0	0.0	0.0	0.0
7- 8	3	2	1	0	0	1	66.7	33.3	0.0	0.0	33.3
9-10	3	0	3	0	0	3	0.0	100.0	0.0	0.0	100.0
11-12	8	5	3	0	0	3	62.5	37.5	0.0	0.0	37.5
13-14	6	4	1	1	0	2	66.7	16.7	16.7	0.0	33.4
15-16	24	11	4	8	1	13	45.8	16.7	33.3	4.2	54.2
17-18	25	10	5	10	0	15	40.0	20.0	40.0	0.0	60.0
19-20	15	3	4	5	3	12	20.0	26.7	33.3	20.0	80.0
21-22	17	6	4	6	1	11	35.3	23.5	35.3	5.9	54.7
23-24	4	0	0	3	1	4	0.0	0.0	75.0	25.0	100.0
Totals	119	55	25	33	6	64	46.2	21.0	27.7	5.0	53.7

maples either moderately or heavily if they used them at all. No tree less than seven to eight inches DBH served as a roost place, but of the smaller size categories which the birds did use, larger percentages than noted for American elms were employed.

The use of Norway maples along the streets, according to size categories, is given in Tables 20 to 22. Although the tendency noted before, in which an increasing DBH was accompanied by an increasing percentage of trees used as roost places, was not very definite in 1950 (Table 20, I&M&H column), it was quite evident in 1951 and 1952 (Tables 21 and 22). Since it was fairly definite in two years and not positively absent in the third, it was concluded that the birds were probably attracted more to the larger Norway maples than to the smaller ones.

The trend of decreasing percentage of use with increasing DBH for lightly used trees, noted for black maples, was not evident for Norway maples. In fact the same trend existed for these trees as for the moderately and heavily used ones. Norway maples, in this respect, were more like the American elms than the black maples. It must be noted, however, that there were fewer Norway maples than black maples from which to draw conclusions.

With the exception of only two trees, with a DBH of only six inches, no Norway maples smaller than seven to eight inches DBH were used for roosting purposes. The exceptionally small trees were both near much larger trees which were extensively used by the birds. The one listed under L in Table 20 was across the street from a group of black maples that were receiving moderate to heavy roosting, and the one under H in

Table 20. Diameters at breast height of Norway maples along the streets and the extent of their use as roost trees on 34 city blocks, August 2 to October 6, 1950.

DBH	No. of trees	Number & per cent according to degree of use									
		Number					Per cent				
		N	L	M	H	L&M&H	N	L	M	H	L&M&H
1- 2	6	6	0	0	0	0	100.0	0.0	0.0	0.0	0.0
3- 4	4	4	0	0	0	0	100.0	0.0	0.0	0.0	0.0
5- 6	3	1	1	0	1	2	33.3	33.3	0.0	33.3	66.6
7- 8	4	4	0	0	0	0	100.0	0.0	0.0	0.0	0.0
9-10	5	5	0	0	0	0	100.0	0.0	0.0	0.0	0. 0
11-12	6	3	1	1	1	3	50.0	16.7	16.7	16.7	50.0
13-14	4	0	2	0	2	4	0.0	50.0	0.0	50.0	100.0
15-16	5	1	0	2	2	4	20.0	0.0	40.0	40.0	80.0
17-18	5	1	2	2	0	4	20.0	40.0	40.0	0.0	80.0
19-20	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
21-22	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
23-24	3	0	2	1	0	3	0.0	66.7	33.3	0.0	100.0
Totals	45	25	8	6	6	20	55.6	17.8	13.3	13.3	44.4

Table 21. Diameters at breast height of Norway maples along the streets and the extent of their use as roost trees on 33 city blocks, June 30 to October 25, 1951.

DBH	No. of trees	Number & per cent according to degree of use									
		Number					Per cent				
		N	L	M	H	L&M&H	N	L	M	H	L&M&H
1- 2	4	4	0	0	0	0	100.0	0.0	0.0	0.0	0.0
3- 4	4	4	0	0	0	0	100.0	0.0	0.0	0.0	0.0
5- 6	3	2	0	1	0	1	66.7	0.0	33.3	0.0	33.3
7- 8	5	2	2	1	0	3	40.0	40.0	20.0	0.0	60.0
9-10	5	2	0	2	1	3	40.0	0.0	40.0	20.0	60.0
11-12	3	2	0	1	0	1	66.7	0.0	33.3	0.0	33.3
13-14	3	0	0	2	1	3	0.0	0.0	66.7	33.3	100.0
15-16	4	1	0	3	0	3	25.0	0.0	75.0	0.0	75.0
17-18	7	1	1	2	3	6	14.3	14.3	28.6	42.9	85.8
19-20	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
21-22	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
23-24	3	0	0	3	0	3	0.0	0.0	100.0	0.0	100.0
Totals	41	18	3	15	5	23	43.9	7.3	36.6	12.2	56.1

Table 22. Diameters at breast height of Norway maples along the streets and the extent of their use as roost trees on 27 city blocks, June 24 to September 2, 1952.

DBH	No. of trees	Number & per cent according to degree of use									
		Number					Per cent				
		N	L	M	H	L&M&H	N	L	M	H	L&M&H
1- 2	4	4	0	0	0	0	100.0	0.0	0.0	0.0	0.0
3- 4	5	5	0	0	0	0	100.0	0.0	0.0	0.0	0.0
5- 6	3	3	0	0	0	0	100.0	0.0	0.0	0.0	0.0
7- 8	5	4	1	0	0	1	80.0	20.0	0.0	0.0	20.0
9-10	4	2	2	0	0	2	50.0	50.0	0.0	0.0	50.0
11-12	4	2	1	1	0	2	50.0	25.0	25.0	0.0	50.0
13-14	4	1	3	0	0	3	25.0	75.0	0.0	0.0	75.0
15-16	6	2	1	3	0	4	33.3	16.7	50.0	0.0	66.7
17-18	4	0	2	2	0	4	0.0	50.0	50.0	0.0	100.0
19-20	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
21-22	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
23-24	2	0	2	0	0	2	0.0	100.0	0.0	0.0	100.0
Totals	41	23	12	6	0	18	56.1	29.3	14.6	0.0	43.9

Table 20, the same tree as listed under M in Table 21, was immediately next to a heavily used American elm tree.

The extent to which the birds roosted in the various sizes of all species of trees, other than American elms and hard maples, is given in Tables 23 to 25. When the data in the I&R&H columns for the three years are used as the basis for comparison, the same general pattern as seen with American elms, although more erratic, is seen for all three years; and the same general trend is noted when the data are examined according to degree of use, though in some of the columns it is not as strongly developed as in others.

With the exception of a downy hawthorn of four inches DBH in 1950, and a hackberry of six inches DBH in 1951, no tree in this general group, trees other than American elms and hard maples, smaller than nine to 10 inches DBH had birds roosting in it during the three years. The small downy hawthorn was overtopped by a much larger hackberry tree which had attracted the birds, and was apparently being used by some of the overflow from it. The six-inch hackberry was across the street from a major black maple roost site and contained only a few birds.

Thus, as far as street trees are concerned, there was a general tendency on the part of the birds to use a greater proportion of the larger trees than of the smaller trees for roosting purposes during three successive years in northeast Ames. The smallest trees were never used by the birds, and, with only four exceptions, only those trees seven to eight inches DBH or larger served as roost places. No tree smaller than four inches DBH was used.

Table 23. Diameters at breast height of all trees along the streets other than American elms and hard maples and the extent of their use as roost trees on 34 city blocks, August 2 to October 6, 1950.

DBH	No. of trees	Number & per cent according to degree of use									
		Number					Per cent				
		N	L	M	H	L&M&H	N	L	M	H	L&M&H
1- 2	7	7	0	0	0	0	100.0	0.0	0.0	0.0	0.0
3- 4	35	34	1	0	0	1	97.1	2.9	0.0	0.0	2.9
5- 6	29	29	0	0	0	0	100.0	0.0	0.0	0.0	0.0
7- 8	19	19	0	0	0	0	100.0	0.0	0.0	0.0	0.0
9-10	16	16	0	0	0	0	100.0	0.0	0.0	0.0	0.0
11-12	14	12	2	0	0	2	85.7	14.3	0.0	0.0	14.3
13-14	17	16	1	0	0	1	94.1	5.9	0.0	0.0	5.9
15-16	11	9	2	0	0	2	81.8	18.2	0.0	0.0	18.2
17-18	10	6	2	2	0	4	60.0	20.0	20.0	0.0	40.0
19-20	7	3	4	0	0	4	42.9	57.1	0.0	0.0	57.1
21-22	8	7	1	0	0	1	87.5	12.5	0.0	0.0	12.5
23-24	8	7	0	0	1	1	87.5	0.0	0.0	12.5	12.5
25-26	8	4	2	2	0	4	50.0	25.0	25.0	0.0	50.0
27-28	4	2	1	1	0	2	50.0	25.0	25.0	0.0	50.0
29-30	7	2	3	2	0	5	28.6	42.9	28.6	0.0	71.5
31-32	6	3	2	1	0	3	50.0	33.3	16.7	0.0	50.0
33-34	5	3	2	0	0	2	60.0	40.0	0.0	0.0	40.0
35-36	2	0	2	0	0	2	0.0	100.0	0.0	0.0	100.0
37-38	2	1	1	0	0	1	50.0	50.0	0.0	0.0	50.0
39-40	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
41-42	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
43-44	1	0	0	0	1	0	0.0	0.0	0.0	100.0	100.0
Totals	216	180	26	8	2	36	83.3	12.0	3.7	0.9	16.6

Table 24. Diameters at breast height of all trees along the streets other than American elms and hard maples and the extent of their use as roost trees on 33 city blocks, June 30 to October 25, 1951.

DBH	No. of trees	Number & per cent according to degree of use									
		Number					Per cent				
		N	L	M	H	L&M&H	N	L	M	H	L&M&H
1- 2	11	11	0	0	0	0	100.0	0.0	0.0	0.0	0.0
3- 4	44	44	0	0	0	0	100.0	0.0	0.0	0.0	0.0
5- 6	36	35	1	0	0	1	97.2	2.8	0.0	0.0	2.8
7- 8	23	23	0	0	0	0	100.0	0.0	0.0	0.0	0.0
9-10	18	16	1	1	0	2	88.8	5.6	5.6	0.0	11.2
11-12	12	12	0	0	0	0	100.0	0.0	0.0	0.0	0.0
13-14	19	14	5	0	0	5	73.7	26.3	0.0	0.0	26.3
15-16	8	7	0	1	0	1	87.5	0.0	12.5	0.0	12.5
17-18	7	4	2	1	0	3	57.1	28.6	14.3	0.0	42.9
19-20	11	9	1	0	1	2	81.8	9.1	0.0	9.1	18.2
21-22	10	7	1	1	1	3	70.0	10.0	10.0	10.0	30.0
23-24	9	6	1	1	1	3	66.7	11.1	11.1	11.1	33.3
25-26	7	4	1	1	1	3	57.1	14.3	14.3	14.3	42.9
27-28	4	1	3	0	0	3	25.0	75.0	0.0	0.0	75.0
29-30	4	2	1	1	0	2	50.0	25.0	25.0	0.0	50.0
31-32	6	3	3	0	0	3	50.0	50.0	0.0	0.0	50.0
33-34	7	3	0	2	2	4	42.9	0.0	28.6	28.6	57.2
35-36	1	0	0	0	1	1	0.0	0.0	0.0	100.0	100.0
37-38	3	1	1	1	0	2	33.3	33.3	33.3	0.0	66.6
39-40	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
41-42	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
43-44	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
45-46	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
47-48	1	1	0	0	0	0	100.0	0.0	0.0	0.0	0.0
Totals	241	203	21	10	7	38	84.2	8.7	4.1	2.9	15.7

Table 25. Diameters at breast height of all trees along the streets other than American elms and hard maples and the extent of their use as roost trees on 27 city blocks, June 24 to September 2, 1952.

DBH	No. of trees	Number & per cent according to degree of use									
		Number					Per cent				
		N	L	M	H	L&M&H	N	L	M	H	L&M&H
1- 2	23	23	0	0	0	0	100.0	0.0	0.0	0.0	0.0
3- 4	79	79	0	0	0	0	100.0	0.0	0.0	0.0	0.0
5- 6	84	84	0	0	0	0	100.0	0.0	0.0	0.0	0.0
7- 8	70	70	0	0	0	0	100.0	0.0	0.0	0.0	0.0
9-10	38	38	0	0	0	0	100.0	0.0	0.0	0.0	0.0
11-12	44	42	2	0	0	2	95.5	4.5	0.0	0.0	4.5
13-14	22	22	0	0	0	0	100.0	0.0	0.0	0.0	0.0
15-16	16	16	0	0	0	0	100.0	0.0	0.0	0.0	0.0
17-18	19	14	2	3	0	5	73.7	10.5	15.8	0.0	26.3
19-20	13	12	1	0	0	1	92.3	7.7	0.0	0.0	7.7
21-22	13	11	1	1	0	2	84.6	7.7	7.7	0.0	15.4
23-24	6	5	1	0	0	1	83.3	16.7	0.0	0.0	16.7
25-26	10	10	0	0	0	0	100.0	0.0	0.0	0.0	0.0
27-28	6	6	0	0	0	0	100.0	0.0	0.0	0.0	0.0
29-30	6	6	0	0	0	0	100.0	0.0	0.0	0.0	0.0
31-32	4	3	1	0	0	1	75.0	25.0	0.0	0.0	25.0
33-34	4	4	0	0	0	0	100.0	0.0	0.0	0.0	0.0
35-36	6	5	0	1	0	1	83.3	0.0	16.7	0.0	16.7
37-38	3	1	2	0	0	2	33.3	66.7	0.0	0.0	66.7
39-40	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
41-42	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
43-44	1	0	0	1	0	1	0.0	0.0	100.0	0.0	100.0
45-46	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
47-48	1	0	1	0	0	1	0.0	100.0	0.0	0.0	100.0
Totals	468	451	11	6	0	17	96.4	2.4	1.3	0.0	3.7

As another approach to the problem, the data were examined for any relationship between the average sizes of the trees used by the birds and the extent or degree to which they used them. To this end the mean DBH's and related data for the various columns in Tables 14 to 25 were computed. These computed data are shown in Tables 26 to 29 and the mean DBH's for the several species are graphed in Figure 3.

Table 26, that gives the data for American elms, indicates that considerable difference existed between the average dimensions of those trees not used as roost and those trees in which the birds did roost. In contrast, no clear picture was obtained for the trees according to degree of use, for the mean DBH's for all three years were different, and in 1951 and 1952 the moderately used trees showed smaller means than for those used lightly. The dimensions for the trees used in 1950 were just the opposite, and furthermore showed a mean DBH for the heavily used trees that was less than for the trees in which roosting occurred on a moderate scale.

Larger means for the lightly used American elms (Table 26) than for the moderately used ones, as obtained in 1951 and 1952, were not unexpected. As noted before, some trees which were actually stopping places, rather than roost trees, were included under light roosting. Because these stopping places, many of which were American elms, were usually larger than nearby trees, they tended to increase the value of the computed mean. No such overlapping between stopping places and moderately used trees was ever noted.

Table 26 shows that the mean sizes for trees used heavily for roosting in 1951 and 1952 were greater than for either light or moderate

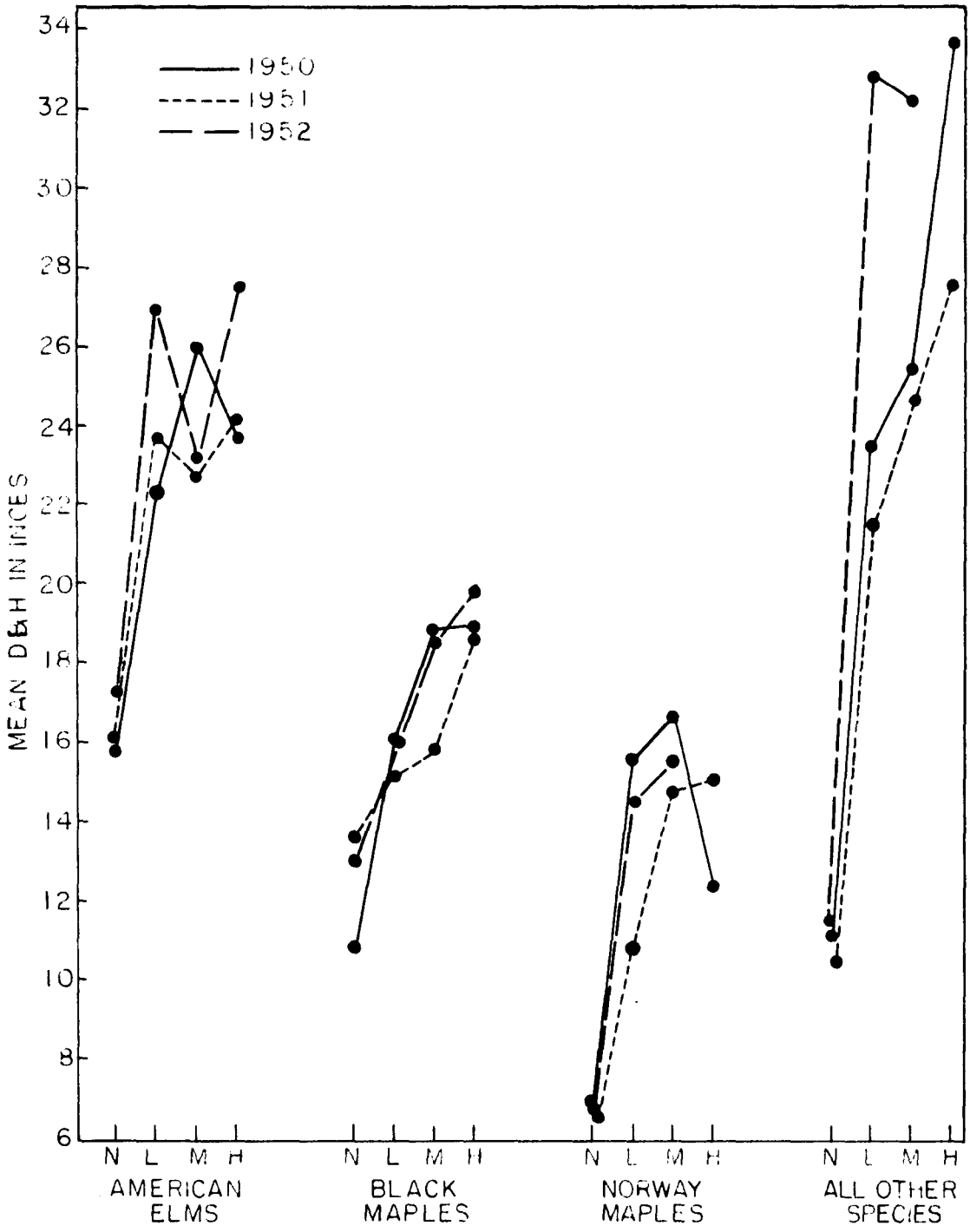


Figure 3. Mean diameters at breast height of street trees and the extent of their use as roost places for three consecutive years.

Table 26. Mean diameters at breast height of American elms near the streets and the extent of their use as roost trees for three consecutive years.

Period of time	No. of blocks	Items	Data according to extent of roosting N	L	M	H	L&M&H
Aug. 2 to Oct. 6, 1950	34	Mean DBH	15.76	22.26	26.03	23.82	23.54
		Stand. dev.*	7.63	7.04	7.10	7.19	7.23
		Stand. error**	.52	.69	1.01	1.18	.53
		No. of trees	215	103	49	37	189
June 30 to Oct. 25, 1951	33	Mean DBH	16.15	23.67	22.67	24.15	23.44
		Stand. dev.	8.23	7.99	5.82	5.52	6.75
		Stand. error	.51	1.03	.84	.95	.57
		No. of trees	257	60	48	34	142
June 24 to Sept. 2, 1952	27	Mean DBH	17.15	26.95	23.12	27.50	25.74
		Stand. dev.	8.69	7.18	3.61	---	5.94
		Stand. error	.54	1.08	.79	---	.73
		No. of trees	260	44	21	1	66

* Standard deviation ** Standard error

Table 27. Mean diameters at breast height of black maples near the streets and the extent of their use as roost trees for three consecutive years.

Period of time	No. of blocks	Items	Data according to extent of roosting N	L	M	H	L&M&H
Aug. 2 to Oct. 6, 1950	34	Mean DBH	10.94	16.24	18.88	18.91	17.71
		Stand. dev.	5.97	3.78	3.39	3.41	3.76
		Stand. error	.92	.58	.64	.66	.38
		No. of trees	43	43	26	27	96
June 30 to Oct. 25, 1951	33	Mean DBH	13.57	15.20	15.82	18.64	15.98
		Stand. dev.	6.37	3.57	2.60	2.54	3.22
		Stand. error	.82	.79	.59	.96	.47
		No. of trees	61	20	19	7	46
June 24 to Sept. 2, 1952	27	Mean DBH	13.03	15.90	18.47	19.83	17.59
		Stand. dev.	6.18	4.32	2.74	2.66	3.68
		Stand. error	.83	.86	.48	1.08	.46
		No. of trees	55	25	33	6	64

roosting, and that the 1950 mean for heavy roosting was greater than the mean for light roosting. Thus, there seemed to be a tendency for the larger trees to receive a greater degree of roosting than smaller ones. However, unless the absence of data for the early part of 1950 was responsible, the situation of a larger mean for the moderately used trees than for either the lightly or heavily used ones, had no explanation other than sampling error. Everything considered, therefore, it was concluded that no clear trend between the average size of the American elms and the degree to which they were used as roost trees existed.

Increasing mean DBH's with increasing degree of roosting were found for black maples in each of the three years. Nevertheless, as Table 27 shows, the situation was not a simple one. The 1951 mean for moderate roosting (15.82 inches) was found to be smaller than either the 1950 or 1952 means for light roosting (16.24 inches and 13.03 inches, respectively); and the 1951 mean for heavy roosting (18.64 inches) was less than the 1950 mean for moderate roosting (18.88 inches). Apparently there was a trend to select the larger trees for the greater degrees of roosting, but the actual sizes used were probably determined by the sizes of the trees present at whatever sites the birds roosted.

A sizeable difference for Norway maples (Table 28) was found to exist between the mean DBH's for those trees not used as a roost and those used by the birds, but the tendency of larger mean DBH's with increasing degrees of roosting again appeared to be a relative matter, as it was with the black maples. The mean DBH's for the moderate degrees of roosting for both 1951 and 1952 were lower than the mean DBH for light roosting in 1950; and the mean DBH for heavy roosting in 1950 (12.5 inches) was lower than

Table 28. Mean diameters at breast height of Norway maples near the streets and the extent of their use as roost trees for three consecutive years.

Period of time	No. of blocks	Items	Data according to extent of roosting N	L	M	H	L&M&H
Aug. 2 to Oct. 6, 1950	34	Mean DBH	6.94	15.75	16.83	12.50	15.10
		Stand. dev.	4.60	5.48	3.93	3.74	4.97
		Stand. error	.92	1.94	1.61	1.53	1.11
		No. of trees	25	8	6	6	20
June 30 to Oct. 25, 1951	33	Mean DBH	6.72	10.83	14.83	15.10	14.37
		Stand. dev.	4.98	5.77	5.69	3.58	5.29
		Stand. error	1.17	3.33	1.46	1.60	1.10
		No. of trees	18	3	15	5	23
June 24 to Sept. 2, 1952	27	Mean DBH	6.80	14.67	15.50	---	14.94
		Stand. dev.	4.41	5.15	2.19	---	4.33
		Stand. error	.92	1.49	.89	---	1.20
		No. of trees	23	12	6	0	18

Table 29. Mean diameters at breast height of all trees near the streets other than American elms and hard maples and the extent of their use as roost trees for three consecutive years.

Period of time	No. of blocks	Items	Data according to extent of roosting N	L	M	H	L&M&H
Aug. 2 to Oct. 6, 1950	34	Mean DBH	11.24	23.50	25.50	33.50	24.50
		Stand. dev.	8.14	8.94	1.69	14.14	8.61
		Stand. error	.61	1.75	.59	10.00	1.44
		No. of trees	180	26	8	2	36
June 30 to Oct. 25, 1951	33	Mean DBH	10.50	21.50	24.70	27.50	23.45
		Stand. dev.	8.37	8.67	8.95	6.53	8.53
		Stand. error	.59	1.89	2.83	2.47	1.38
		No. of trees	203	21	10	7	38
June 24 to Sept. 2, 1952	27	Mean DBH	11.40	32.83	32.17	---	32.61
		Stand. dev.	8.41	9.36	6.66	---	10.49
		Stand. error	.61	3.82	3.84	---	3.50
		No. of trees	189	6	3	0	9

any of the values for light or moderate roosting, with the exception of light roosting in 1951. The differences between the values for light roosting and moderate roosting, and between moderate and heavy, were not as great as the corresponding differences for black maples. A tendency to use larger Norway maples for greater degrees of roosting than smaller trees, with the exception of the heavily used trees in 1950, seemed to be present but it was not as strongly developed as with the black maples. It must be noted that the means were based on few trees in each category.

Data for all other species of trees, comparable to those just discussed for American elms and hard maples, are presented in Table 29. The birds in 1950 and 1951 seemingly roosted in the various trees in proportion to average tree size, but some of the means were based on very few trees. The 1952 means, on the other hand, showed a somewhat different pattern, with the means for moderate roosting and light roosting almost identical, but they were based on even fewer data than were available for the other two years.

The differences between the means in the N column and the I&M&H column for all groups of trees and for all three years (Tables 26 to 29) were tested for significance using the t-test. With the exception of the 1951 data in Table 27, which tested significant at the 5 per cent level, all other differences between the means were significant at the 1 per cent level. Within a species of tree, at least, the birds showed a definite tendency to select the larger trees as roost places.

Interspecifically, as Figure 3 and Tables 26 to 29 indicate, the story was a little different. The birds roosted in hard maples with

average DBH's that were ignored in the American elms. Clearly size was not the only criterion that caused birds to roost in certain trees and to ignore others.

In summary, of the four groups of trees just discussed (American elms, black maples, Norway maples, all other species), only the black maples showed a clear tendency to have the greatest degree of roosting occur in the largest trees. Norway maples and "all other species" showed the same tendency to a lesser degree, and American elms had no special pattern. In each species of tree the birds roosted in larger trees and ignored the smaller ones, but the same sizes in different species of trees did not have the same ability to attract the birds.

Annual summaries for back yard trees. The roosting use of the several species of trees in back yards, according to their DBH's, is given for 1951 and 1952 in Tables 30 and 31. Because few back yard trees were used by the birds, only the I&M&H data, here designated as "used as roost" were included. As Table 30 reveals, the American elms in back yards showed the same tendency of a general increase in percentage of use as the DBH increased as was noted for street trees. Based on few trees, the trend was rather erratic, and was almost non-existent in 1952.

No tables were prepared for either of the hard maples in back yards. In 1951 no black maples in such locations were used by the birds, although seven were present on the 33 city blocks summarized for other species of trees. All seven trees were well within the size limits used for roosting purposes, with a range of nine to 10 inches to 25 to 26 inches DBH. Of the seven black maples on the 27 city blocks summarized for 1952, four

Table 30. Diameters at breast height of American elms in back yards and the extent of their use as roost sites in 1951 and 1952.

DBH	1951			1952		
	No. of trees	Used as roost		No. of trees	Used as roost	
		Number	Per cent		Number	Per cent
1- 2	0	0	0.0	0	0	0.0
3- 4	6	0	0.0	6	0	0.0
5- 6	9	0	0.0	7	0	0.0
7- 8	10	0	0.0	13	0	0.0
9-10	14	0	0.0	14	0	0.0
11-12	16	1	6.3	16	1	6.3
13-14	13	1	7.7	13	4	30.8
15-16	9	0	0.0	9	3	33.3
17-18	11	1	9.0	8	0	0.0
19-20	7	1	14.3	4	0	0.0
21-22	8	3	37.5	7	1	14.3
23-24	4	0	0.0	2	0	0.0
25-26	4	0	0.0	6	0	0.0
27-28	6	0	0.0	3	0	0.0
29-30	2	0	0.0	2	0	0.0
31-32	2	0	0.0	3	1	33.3
33-34	2	1	50.0	2	0	0.0
35-36	1	1	100.0	1	0	0.0
37-38	0	0	0.0	0	0	0.0
39-40	0	0	0.0	0	0	0.0
41-42	1	0	0.0	2	1	50.0
43-44	1	0	0.0	1	0	0.0
Totals	126	9	7.2	119	11	9.2

Table 31. Diameters at breast height of all trees in back yards other than American elms and hard maples and the extent of their use as roost sites in 1951 and 1952.

DBH	1951			1952		
	No. of trees	Used as roost		No. of trees	Used as roost	
		Number	Per cent		Number	Per cent
1- 2	7	0	0.0	17	0	0.0
3- 4	48	0	0.0	46	0	0.0
5- 6	54	0	0.0	49	0	0.0
7- 8	46	2	4.7	49	0	0.0
9-10	27	0	0.0	19	0	0.0
11-12	39	4	10.3	34	2	5.9
13-14	17	3	17.7	11	0	0.0
15-16	13	2	15.4	7	0	0.0
17-18	14	0	0.0	11	4	36.4
19-20	8	1	12.5	5	0	0.0
21-22	9	2	22.2	7	2	28.6
23-24	2	1	50.0	1	0	0.0
25-26	6	1	16.7	5	0	0.0
27-28	1	0	0.0	2	0	0.0
29-30	0	0	0.0	1	0	0.0
31-32	1	1	100.0	0	0	0.0
33-34	1	1	100.0	1	0	0.0
35-36	3	2	66.6	4	0	0.0
37-38	0	0	0.0	1	0	0.0
39-40	1	1	100.0	0	0	0.0
Totals	297	21	7.1	270	8	3.0

were used as roost trees. All four were large trees, with a range in DBH from 21 to 26 inches. Only one Norway maple (24 inches DBH), of the six trees present, was a roost tree in 1951; and only two trees (12 inches and 24 inches DBH), of the seven present, served the birds in 1952. Size probably was not the factor that prevented the birds from using more of the Norway maples, however, for in both years all of the trees of this species, with only one exception, were nine to 10 inches DBH or larger.

Table 31 gives the results of the observations made on all species of trees in the back yards other than American elms and hard maples. In 1951 there was increasing percentage of use with an increase in tree size, but in 1952 too few trees were used to warrant any conclusions. In both years more than 80 trees were present of the size used by the birds along the streets, including some as large as 35 to 36 inches DBH or larger. Therefore tree dimensions again were not the factors that prevented the birds from using more back yard trees as roost places.

When the mean DBH's of the several species of back yard trees were computed and compared, with the precaution in mind that very few roost trees were represented, some of the same conclusions made for the street trees were reached. The pertinent data, given in Tables 32 to 35, indicated that the trees not used by the birds had considerably smaller mean DBH's than the trees which did serve as roost places. Further evidence, obtained when the differences between these means in the four tables were subjected to t-tests, showed that both of those for Table 33 were significant at the 1 per cent level, and those for American elms in 1951 (Table 32) at 5 per cent. The differences between the means for American

Table 32. Mean diameters at breast height of American elms in back yards and the extent of their use as roost trees for two consecutive years.

Period of time	No. of blocks	Items	Data according to extent of roosting N	L	M	H	L&M&H
June 30 to Oct. 25, 1951	33	Mean DBH	14.49	24.83	15.50	---	21.28
		Stand. dev.	8.14	7.66	5.29	---	8.09
		Stand. error	.75	3.05	3.06	---	2.69
		No. of trees	117	6	3	0	9
June 24 to Sept. 2, 1952	27	Mean DBH	14.78	18.50	19.10	---	18.77
		Stand. dev.	8.65	11.37	7.67	---	9.39
		Stand. error	.83	4.64	3.43	---	2.83
		No. of trees	108	6	5	0	11

Table 33. Mean diameters at breast height of all trees in back yards other than American elms and hard maples and the extent of their use as roost trees for two consecutive years.

Period of time	No. of blocks	Items	Data according to extent of roosting N	L	M	H	L&M&H
June 30 to Oct. 25, 1951	33	Mean DBH	9.31	19.40	17.10	35.50	19.98
		Stand. dev.	5.74	10.70	5.18	---	9.98
		Stand. error	.35	2.76	2.32	---	2.18
		No. of trees	276	15	5	1	21
June 24 to Sept. 2, 1952	27	Mean DBH	9.18	15.90	18.83	---	17.00
		Stand. dev.	6.92	4.34	2.31	---	3.82
		Stand. error	.43	1.94	1.33	---	1.35
		No. of trees	262	5	3	0	8

Table 34. Mean diameters at breast height of black maples in back yards and the extent of their use as roost trees for two consecutive years.

Period of time	No. of blocks	Items	Data according to extent of roosting N	L	M	H	L&M&H
June 30 to Oct. 25, 1951	33	Mean DBH	20.07	---	---	---	---
		Stand. dev.	5.38	---	---	---	---
		Stand. error	2.19	---	---	---	---
		No. of trees	7	0	0	0	0
June 24 to Sept. 2, 1952	27	Mean DBH	15.50	23.50	23.50	---	23.50
		Stand. dev.	5.29	2.83	---	---	1.63
		Stand. error	3.05	2.00	---	---	.82
		No. of trees	3	2	2	0	4

Table 35. Mean diameters at breast height of Norway maples in back yards and the extent of their use as roost trees for two consecutive years.

Period of time	No. of blocks	Items	Data according to extent of roosting N	L	M	H	L&M&H
June 30 to Oct. 25, 1951	33	Mean DBH	9.50	23.50	---	---	23.50
		Stand. dev.	6.00	---	---	---	---
		Stand. error	2.68	---	---	---	---
		No. of trees	5	1	0	0	1
June 24 to Sept. 2, 1952	27	Mean DBH	11.10	17.50	---	---	17.50
		Stand. dev.	5.18	8.49	---	---	8.49
		Stand. error	2.32	6.00	---	---	6.00
		No. of trees	5	2	0	0	2

elms in 1952 (Table 32), on the other hand, were non-significant. Similar analyses for the hard maples indicated significance at 5 per cent for the black maples in 1952 (Table 34) and non-significance for the Norway maples that same year (Table 35).

When the records for American elms were checked according to degree of use, no clear picture was obtained. Table 32 shows that in 1951 the mean DBH for light roosting in back yard American elms was considerably greater than that for moderately used trees, but that in 1952 the reverse was true. Thus, there was the same type of reversal of trends in back yard American elms as was shown for the trees along the streets, but the years involved were not the same. A reversal of trends was also noted for the DBH's of "all other species" in back yards (Table 33). No conclusions for the birds' use of the hard maples according to degree of use were possible, because few roost trees were concerned (Tables 34 and 35).

Everything considered, no clear trend between degree of use and the mean DBH was indicated for the birds' use of back yard trees. All that seemed definite was that roost trees were of larger mean DBH than the non-roost trees.

Street trees and back yard trees directly compared. With the exception of the hard maples, as shown by Table 36, street trees in the northeast Ames study area had a larger average DBH than the back yard trees of the same species. This relationship was found for all trees present and also for those trees used as roost places. The hard maples were just the reverse, and though they were fewer in number in back yards than along the streets, they were larger on the average in the former location. Without

Table 36. Street trees versus back yard trees for two consecutive years.

Tree species	Year	Items	Street trees		Back yard trees	
			All trees present	Used as roost	All trees present	Used as roost
American elms	1951	Mean DBH	18.75	23.44	15.63	21.28
		Stand. dev.	8.48	6.75	8.33	8.09
		Stand. error	.42	.57	.74	2.69
		No. of trees	399	142	126	9
	1952	Mean DBH	18.45	25.74	15.32	18.77
		Stand. dev.	8.92	5.94	8.76	9.39
		Stand. error	.49	.73	.80	2.83
		No. of trees	326	66	119	11
Black maples	1951	Mean DBH	14.60	15.98	20.07	---
		Stand. dev.	5.36	3.22	5.38	---
		Stand. error	.52	.47	2.19	---
		No. of trees	107	46	7	0
	1952	Mean DBH	15.48	17.59	20.07	23.50
		Stand. dev.	5.47	3.68	5.38	1.63
		Stand. error	.50	.46	2.34	.82
		No. of trees	119	64	7	4
Norway maples	1951	Mean DBH	11.01	14.37	11.83	23.50
		Stand. dev.	6.35	5.29	7.84	---
		Stand. error	.99	1.10	3.20	---
		No. of trees	41	23	6	1
	1952	Mean DBH	10.38	14.94	12.93	17.50
		Stand. dev.	5.95	4.33	6.29	8.49
		Stand. error	.93	1.20	2.38	6.00
		No. of trees	41	18	7	2
All other trees	1951	Mean DBH	12.53	23.45	10.07	19.98
		Stand. dev.	9.68	8.53	6.69	9.98
		Stand. error	.62	1.38	.39	2.18
		No. of trees	241	38	297	21
	1952	Mean DBH	12.37	32.61	9.41	17.00
		Stand. dev.	9.57	10.49	6.78	3.82
		Stand. error	.68	3.50	.41	1.35
		No. of trees	198	9	270	8

exception, in any one year and within any one species, the mean DBH of the trees used as roost places was larger than the mean DBH of all the trees present of that species. This relationship was a relative one, however, for the mean DBH's of some species used as roost, in at least one of the years, were smaller than the mean DBH's of the total population of other tree species for at least one of the years. For example, as Table 36 shows, the mean DBH of back yard "all other species" used as roost in 1952 (17 inches) was smaller than the mean DBH of all American elms present along the streets in 1951 (18.75 inches) or 1952 (18.45 inches). Also the mean DBH of the Norway maple street roost trees in 1951 (14.37 inches) was less than the mean DBH of all black maples present along the street in either year (14.60 inches and 15.48 inches, respectively). The birds' use of the larger trees, therefore, was a relative matter between tree species, and even within the species was not a fixed entity, as was shown by the variations from one year to the next.

Changes with the season. Because few back yard trees were used as roost places on any one date when an inspection of the roost was made, data were insufficient to consider any possible changes with the advancing season.

Use of trees according to nearness to other trees

Preliminary comments. After the present investigation had gotten well under way, the impression grew upon the writer that, whenever possible, the birds tended to use trees that were closely grouped. This seemed especially to be true in late June when the nuclei for the roost sites were established. Later, as the birds increased in numbers and

overflowed to nearby trees, the tendency was not always as clearly in evidence, but still seemed to exist at least in certain localities.

To learn whether the birds' use of the more closely grouped trees was a fact or not, the mean distances from roost trees to the nearest two trees, and from non-roost trees to the nearest two trees, were computed. Distances measured were from center of trunk to center of trunk. For purposes of the present section only those trees of roost size, seven to eight inches DBH or larger, were considered, and only those city blocks on which at least three roost trees were present were entered in the tabulations.

Measurements for street trees were made from tree to tree along the street except where irregular plantings dictated otherwise. Distances to trees across the street were ignored unless trees thus located happened to be the nearest ones to the trees under consideration. Measurements for back yard trees were made from tree to tree in whatever direction was required. If a back yard tree happened to be 50 feet or less from a street tree, that distance was included with the back yard data to get the second measurement for a tree if necessary. If a back yard tree was closer to a street tree than to any other back yard tree, the distance to the street tree was used as a back yard datum. If a roost tree was between two non-roost trees, or if a non-roost tree was between two roost trees, then the pertinent distances were entered in both the roost tree tabulations and in the non-roost tree tabulations.

Nearness of street trees. Without exception, as shown by Table 37 and Figure 4, calculations showed that the average distance from roost

Table 37. Use of street trees as roost places as related to nearness of other trees.

Date		No. of blocks	Types of trees	No. of distances measured	Mean distance apart (ft.)	Stand. dev.	Stand. error
1950	Aug. 2	13	Roost	162	33.46	13.32	1.05
			Non-roost	153	35.68	13.96	1.12
	Sept. 14	21	Roost	228	33.02	13.35	.88
			Non-roost	339	34.84	13.97	.76
	Oct. 6	16	Roost	159	34.10	14.18	1.12
			Non-roost	246	36.72	13.25	.84
	Summary	31	Roost	404	33.80	13.83	.69
			Non-roost	364	36.02	14.02	.73
1951	June 30	7	Roost	57	31.68	13.35	1.77
			Non-roost	140	35.21	16.32	1.38
	July 16	10	Roost	100	34.50	15.43	1.54
			Non-roost	159	35.58	15.48	1.23
	Aug. 11	14	Roost	151	36.05	15.45	1.26
			Non-roost	167	37.31	16.33	1.26
	Aug. 30	12	Roost	134	33.93	14.43	1.25
			Non-roost	167	35.16	13.93	1.08
	Oct. 5	11	Roost	95	32.53	12.86	1.32
			Non-roost	162	34.64	15.32	1.20
	Oct. 25	10	Roost	84	33.18	12.47	1.36
			Non-roost	180	34.67	14.56	1.09
	Summary	26	Roost	290	35.27	15.88	.93
			Non-roost	306	36.81	15.42	.88

Table 37. (Continued)

Date	No. of blocks	Types of trees	No. of distances measured	Mean distance apart (ft.)	Stand. dev.	Stand. error
1952 June 24	9	Roost	72	32.44	11.37	1.34
		Non-roost	123	33.77	13.12	1.18
July 11	6	Roost	59	28.08	11.65	1.52
		Non-roost	103	34.07	13.87	1.37
Aug. 6	7	Roost	70	30.57	12.59	1.50
		Non-roost	96	35.55	15.68	1.60
Sept. 2	9	Roost	86	33.99	12.78	1.38
		Non-roost	142	34.97	15.50	1.30
Summary	18	Roost	179	31.97	12.10	.95
		Non-roost	250	34.18	14.54	.92

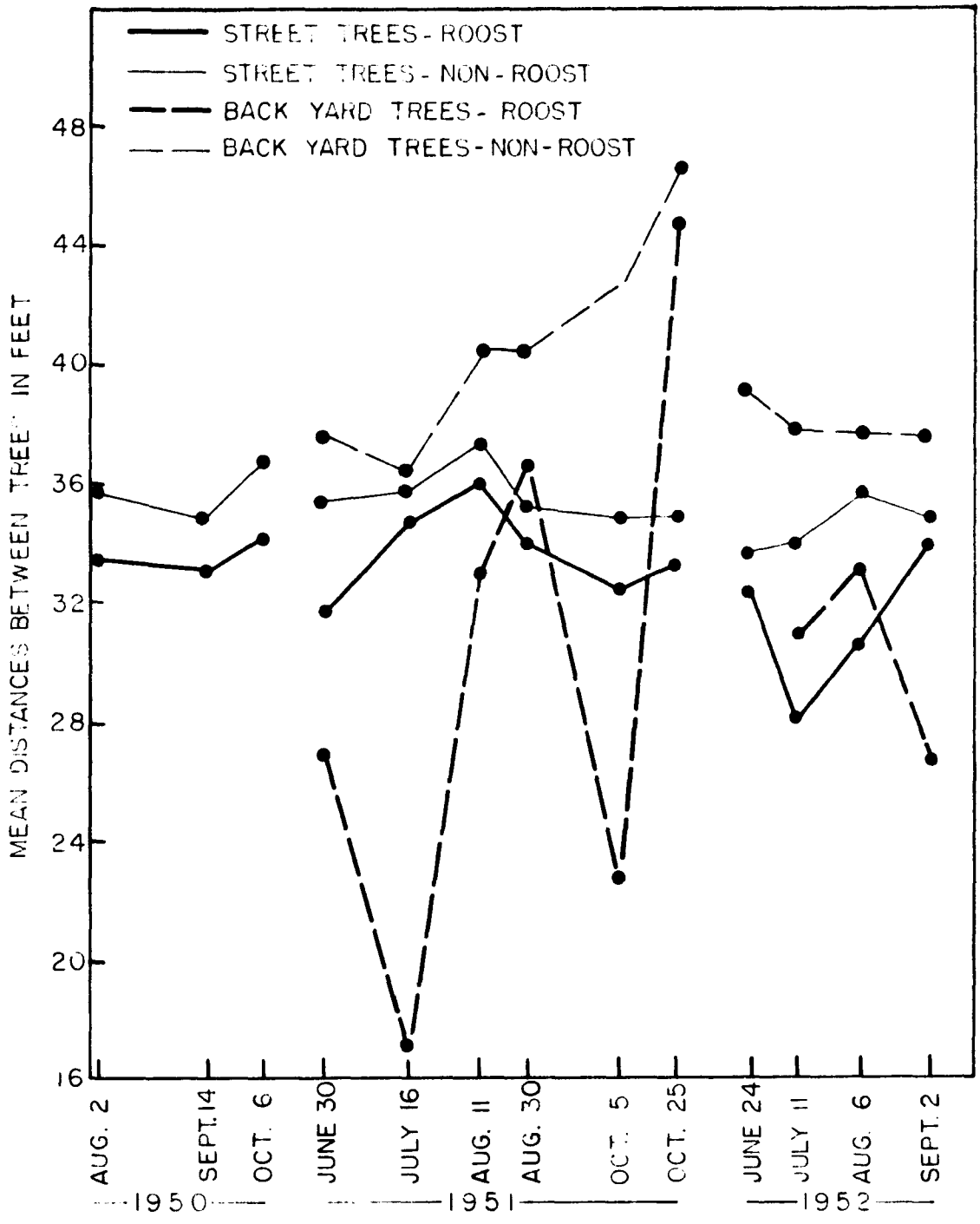


Figure 4. Use of trees as roost places as related to nearness of other trees.

trees to the nearest trees was less than the corresponding average from non-roost trees to the nearest trees. This relationship was found for the roost as determined at various times during the season and also for the annual summaries. The birds, on the average, used the more closely grouped trees throughout all three years.

As was true for the mean DBH's, the picture was not a simple one, for, as is shown in Table 37, the mean distances varied from month to month and also from year to year. Several mean distances for roost trees were actually greater than were some mean distances for non-roost trees. For example, the average distances for roost trees for July 16 and August 11, 1951, were 34.50 feet and 36.05 feet, respectively, but the average distances for non-roost trees for June 24 and July 11, 1952, were 33.77 feet and 34.07 feet, respectively. Apparently the birds' use of the more closely grouped trees was a relative matter. At whatever sites the birds roosted, whenever possible they used the more closely planted trees, but the closeness of the trees at one site was not always the same as at another site.

There is little evidence from Table 37 that the birds followed any particular trends in the use of groupings of trees, for the changing pattern from month to month was not the same for all three years. About the only common element was the narrowness of the range of the means. Several changes noted had probable explanations. The increase in the mean dimensions from September 14 to October 6, 1950, and from October 5 to October 25, 1951, were apparently related to the changes in sites caused by the fall of leaves. The 1950 changes came earlier because high winds in late September had caused considerable loss of cover. When the birds

moved to new sites they apparently had to choose places where the trees were farther apart. The small average distances for roost trees (Table 37) for July 11 and August 6, 1952, were related to the use of the closely planted hard maples on Duff Avenue and Carroll Avenue. As the birds used other sites in addition by September 2, the mean distances between the trees increased.

The close parallel between roost tree mean distances and non-roost tree mean distances, which is indicated in Table 37 and Figure 4, was probably caused by the manner in which the data were handled for purposes of this section. Numerous situations presented themselves where a roost tree was flanked by non-roost trees, or where a non-roost tree had a roost tree on either side of it. Since by definition the distances between such trees had to be tabulated with both the roost tree data and the non-roost tree data, there was considerable tendency to equalize the two means. Despite this, the tendency of the birds to use the more closely grouped trees was apparently strong enough to show consistently smaller mean distances for the roost trees.

When the differences between the means for the annual summaries were compared statistically, t-tests showed the 1950 mean distances to differ significantly at the 5 per cent level, but those for the 1951 and 1952 data were not significant. In the light of the tendency to equalize the means because of the manner of computation, it is probably surprising to have even one set of the mean differences test significant, but it does lend support to the conclusion that grouping of trees was important to the birds.

Nearness of back yard trees. Table 38 and Figure 4 give the results for back yard trees. Again, without exception, on any one date or for either annual summary, the mean distance for the roost trees was smaller than for non-roost trees. Yet, as was true for street tree data, several roost tree mean distances were larger than some non-roost tree mean distances. The birds' use of the more closely grouped trees was again a relative matter. Though there seemed to be a definite increase in the size of the averages for both roost trees and non-roost trees as the season advanced in 1951, results obtained in 1952 did not follow this pattern. Data gathered were really too limited to establish seasonal trends. Furthermore, except for the fact that roost tree mean distances were less than those for non-roost trees, there was no particular correspondence with street tree data.

The differences between the means for the annual summaries in Table 38 were treated statistically in the same manner as for the street tree data already discussed. The t-tests indicated non-significance for the 1951 data, but significance at the 5 per cent level for the 1952 mean differences. Thus, despite the method of computing the nearness of trees, with its considerable tendency to equalize the means, at least one of the mean differences tested significant. The birds apparently tended to use the more closely grouped trees whenever possible.

Of special interest were the greater distances that generally were found between trees in back yards than between street trees. As can be seen in Figure 4, or by comparing Tables 37 and 38, these greater distances resulted in greater average distances between non-roost trees.

Table 38. Use of back yard trees as roost places as related to nearness of other trees.

Date		No. of blocks	Types of trees	No. of distances measured	Mean distance apart (ft.)	Stand. dev.	Stand. error
1951	June 30	7	Roost	5	26.80	22.43	10.03
			Non-roost	57	37.56	23.05	3.05
	July 16	10	Roost	4	17.25	7.93	3.97
			Non-roost	87	36.45	23.06	2.47
	Aug. 11	14	Roost	18	33.00	23.95	5.64
			Non-roost	101	40.57	22.53	2.24
	Aug. 30	12	Roost	7	36.71	23.41	8.85
			Non-roost	71	40.56	23.74	2.82
	Oct. 5	11	Roost	3	22.67	7.51	3.93
			Non-roost	63	42.76	23.13	2.91
	Oct. 25	10	Roost	11	44.82	22.94	6.92
			Non-roost	86	46.66	22.91	2.47
	Summary	26	Roost	30	39.83	21.23	3.88
			Non-roost	178	40.02	23.49	1.76
1952	June 24	9	Roost	0	---	---	---
			Non-roost	49	39.22	22.63	3.23
	July 11	6	Roost	14	30.86	14.64	3.91
			Non-roost	93	38.00	19.17	1.99
	Aug. 6	7	Roost	20	33.25	16.82	3.76
			Non-roost	79	37.94	17.93	2.17
	Sept. 2	9	Roost	15	26.67	14.32	3.70
			Non-roost	123	37.80	19.90	1.79
	Summary	18	Roost	27	30.59	16.31	3.14
			Non-roost	170	39.03	20.60	1.58

On the other hand, trees selected as roost places in back yards, were not, generally speaking, farther apart than roost trees along the streets. As indicated by the tables and the figure, some were even closer together. Apparently there were not very many close groupings of roost-size trees in back yards, however, and the relative absence of such may well have been a primary reason for the small percentages of back yard trees used as roost places.

Use of trees according to amount of cover

The two methods of tabulating the data. As is explained in detail in the section "Method of Procedure", 20 readings per tree were made of the light coming through the tree crowns between 11:00 A. M. and 1:00 P. M. on days when sky conditions were uniform. The average of these 20 readings was then expressed as a percentage of the light in the open and used as an index of the amount of cover provided by the foliage. A large percentage indicated little cover, and a small percentage much cover. A total of 23 noons, from July 3 to October 24, 1952, were occupied in getting such readings. The majority were obtained during July when sky conditions were unusually favorable. Readings were taken on 16 city blocks, and some of the blocks were checked several times during the course of the season.

Table 39, discussed in the next section, was based on the assumption that cover conditions did not change materially from late June to early September. Under this assumption all light readings taken during the summer were tabulated against the degrees of use of the trees as determined on each of the periodic checks during this time. This made it possible to deal with a greater quantity of data, because the number of

trees that could be measured for cover density on any one noon was somewhat limited. The results are also shown in Figure 5.

Table 40, discussed in the next section, was based on the alternate assumption that cover conditions may have changed materially during the summer. Consequently, with the exception of the October data, the cover density measurements were tabulated only against those degrees of use of the trees as determined within two weeks or less of the light readings. In October, when cover changes were obvious and rapid, the light readings and degree of use determinations were made on the same days. Figure 6 shows the results graphically.

Relation between degree of use and amount of cover. On the assumption that there were no material changes in cover between June 24 and September 10, 1952, the data showed that in the American elms (Table 39 and Figure 5) there was a definite trend on the part of the birds to give higher degrees of use to trees which provided the most cover. For each of the four days on which the roosting degrees were checked, Table 39 shows that, in going up the scale of degrees of use, there were progressive decreases in per cent of light getting through the crowns. Furthermore, the average per cent of light getting through all trees used by the birds (shown in the I&M&H column) in each case was less than the per cent shown for those trees not used by the birds (N column).

Although they were on a considerably milder scale, similar trends, with the exception of the August 6 data, seemed to be indicated for the black maples (Table 39). In line with their obviously heavier foliage, the percentages were much lower on the average than those given for the American elms, and, as was to be expected if the birds used the denser

Table 39. Relation of cover density readings to degree of roosting, assuming the cover did not change materially from June 24 to September 10, 1952.

Species of trees	Date of roosting check	No. of blocks light was measured	Degree of roosting: N No. of trees	N % of light	L No. of trees	L % of light	M No. of trees	M % of light	H No. of trees	H % of light	L&M&H No. of trees	L&M&H % of light
Elm, American	June 24	9	61	7.06	17	6.71	8	4.96	0	—	25	6.15
	July 11	8	58	5.92	10	3.74	4	1.79	0	—	14	3.18
	Aug. 6	10	67	5.75	14	4.66	6	2.23	0	—	20	3.93
	Sept. 2	8	48	4.65	10	4.18	7	2.02	0	—	17	3.29
Maple, Black	June 24	9	20	0.96	6	0.58	2	0.44	0	—	8	0.55
	July 11	8	24	1.40	18	1.46	18	0.66	0	—	36	1.06
	Aug. 6	10	26	0.97	18	0.87	20	1.10	4	1.01	42	0.99
	Sept. 2	8	34	1.14	13	0.97	11	0.76	4	0.38	28	0.80
Maple, Norway	June 24	9	11	1.00	7	0.70	2	2.78	0	—	9	1.16
	July 11	8	5	0.66	2	0.28	0	—	0	—	2	0.28
	Aug. 6	10	6	0.86	2	0.28	0	—	0	—	2	0.28
	Sept. 2	8	0	—	3	3.26	1	1.86	0	—	4	2.91
All other species	June 24	9	31	6.19	1	16.50	2	6.09	0	—	3	9.56
	July 11	8	12	6.36	2	13.56	0	—	0	—	2	13.56
	Aug. 6	10	16	7.20	0	—	1	1.22	0	—	1	1.22
	Sept. 2	8	12	6.59	1	6.87	1	1.22	0	—	2	4.05

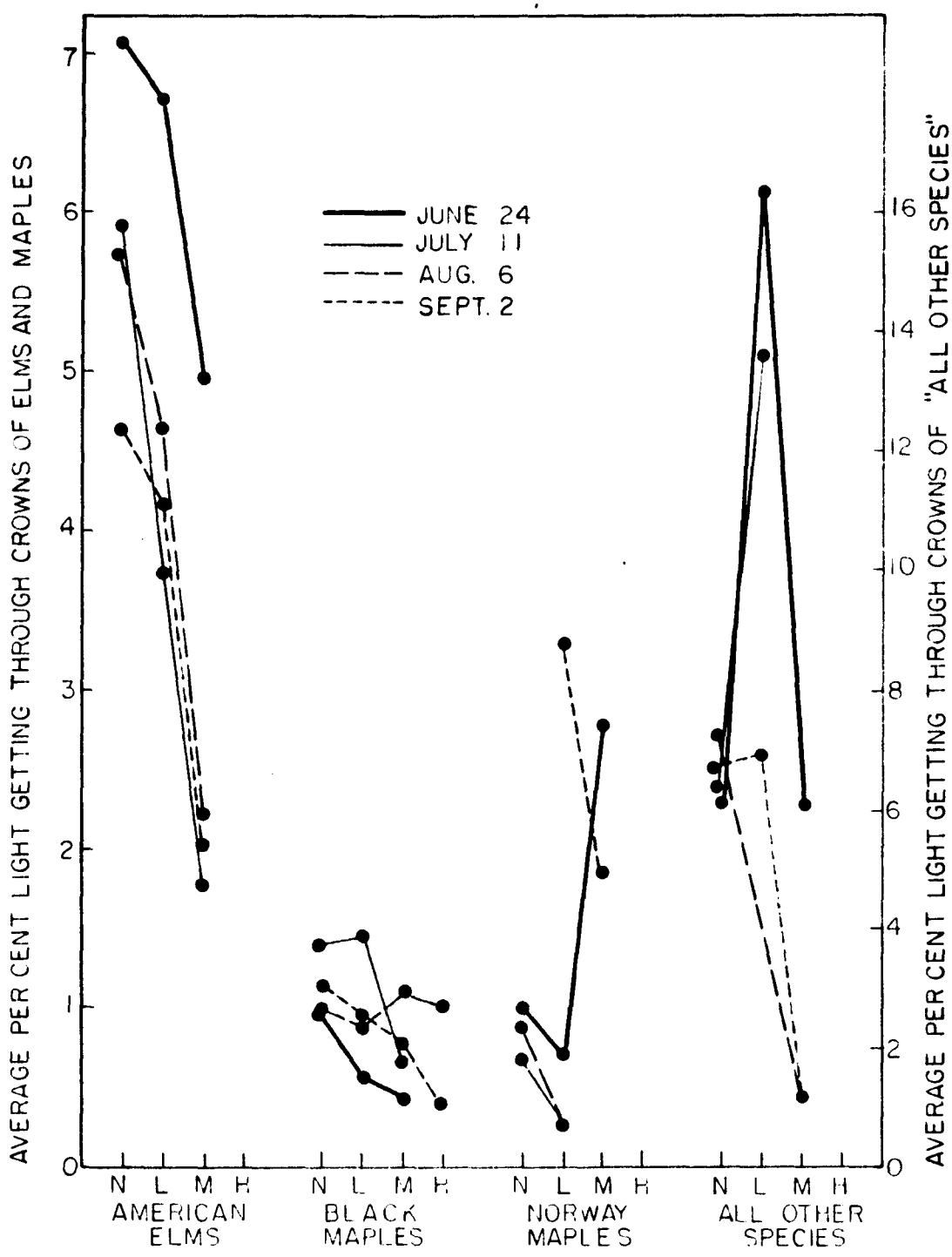


Figure 5. Cover density and degree of roosting on the assumption that cover did not change materially during the summer of 1952.

trees more heavily, the percentages for trees not used for roosting were higher than those used (L&M&H column in the table). The data for August 6, however, did not fall into the general pattern of lower percentages associated with higher degrees of use. Likewise the percentage, 1.46, which was noted for lightly used trees on July 11, did not fit in with the general pattern since it was slightly higher than the percentage for trees not used, 1.40. Norway maples tended to follow the overall trends shown by the black maples, as is indicated in Table 39, but the data were more limited. "All other species" did not show any special pattern.

On the assumption that the cover did change during the season, the light measurements, summarized in Table 40, showed the same general pattern for American elms as shown by Table 39. Only two percentages were out of line, but they were based on only one tree in each case. On the other hand, the percentages for black maples (Table 40), through the October 4 to 10 period, presented a very confusing picture and did not indicate any definite trends. If anything, they tended to accentuate the exceptions to the basic trends shown in Table 39. Data for Norway maples and "all other species" also showed no consistent trends, but the data were quite limited.

When all evidence was summed, therefore, it was concluded that the birds tended to use the American elms selectively for cover, and used more intensively those elms that were denser. The tendency to use trees with heavier cover reached its culmination in the hard maples in Ames, for elsewhere in this thesis it is shown that a larger percentage of hard maples than of American elms was used by the birds. Once within the range of cover provided by the hard maples, however, the variations in the densities of individual trees apparently had little if any effect

Table 40. Relation of cover density readings to degree of roosting, assuming the cover may have changed materially from July 2 to October 24, 1952.

Species of trees	Date of roosting check	No. of blocks light was measured	Degree of roosting: N — No. of trees	N — % of light	L — No. of trees	L — % of light	M — No. of trees	M — % of light	H — No. of trees	H — % of light	L&M&H — No. of trees	L&M&H — % of light
Elm, American	July 11	5	28	5.46	9	3.85	4	1.79	0	—	13	3.22
	Aug. 6	3	22	5.09	0	—	1	4.90	0	—	1	4.90
	Sept. 2	1	9	5.36	0	—	0	—	0	—	0	—
	Oct. 4-10	5	10	23.10	13	22.35	6	20.10	8	18.14	27	20.60
	Oct.20-24	3	14	57.04	8	49.41	6	33.56	1	36.84	15	42.23
Maple, Black	July 11	5	12	0.85	15	1.55	18	0.66	0	—	33	1.07
	Aug. 6	3	16	1.24	2	1.86	3	1.14	1	2.01	6	1.34
	Sept. 2	1	0	—	1	1.42	2	0.48	0	—	3	0.79
	Oct. 4-10	5	1	3.69	5	9.43	6	22.25	9	12.26	20	14.55
	Oct.20-24	3	7	47.94	0	—	1	44.25	0	—	1	44.25
Maple, Norway	July 11	5	5	0.66	2	0.28	0	—	0	—	2	0.28
	Aug. 6	3	1	1.86	0	—	0	—	0	—	0	—
	Sept. 2	1	0	—	3	3.26	0	—	0	—	3	3.26
	Oct. 4-10	5	0	—	2	3.39	2	7.33	2	12.04	6	7.54
	Oct.20-24	3	6	33.62	2	36.34	1	12.40	0	—	3	28.36
All other species	July 11	5	12	6.37	2	13.56	0	—	0	—	2	13.56
	Aug. 6	3	2	4.98	0	—	0	—	0	—	0	—
	Sept. 2	1	3	4.50	0	—	0	—	0	—	0	—
	Oct. 4-10	5	3	12.10	2	7.44	1	10.57	0	—	3	8.49
	Oct.20-24	3	12	52.78	3	42.21	2	32.62	0	—	5	38.37

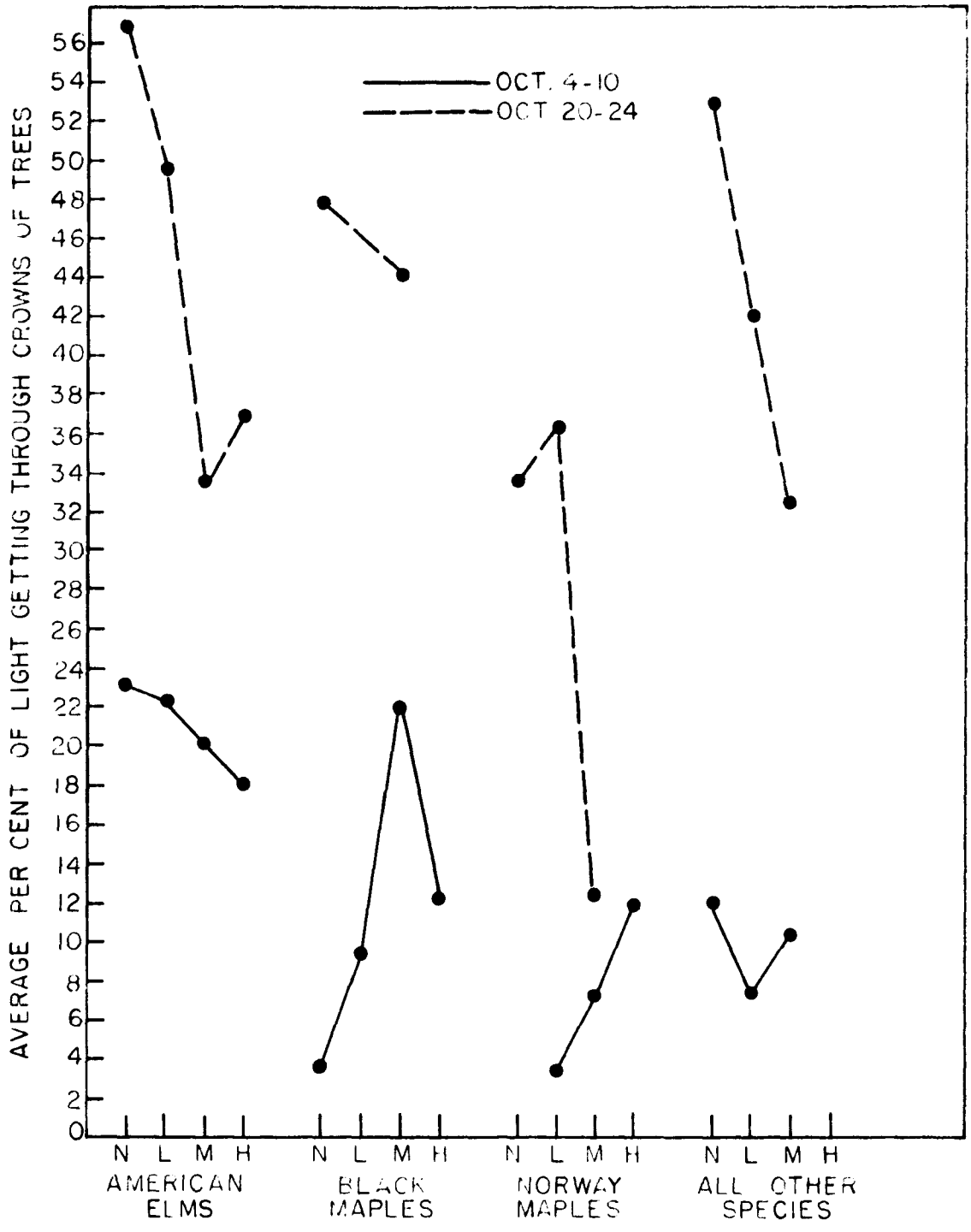


Figure 6. Cover density changes during October, 1952.

on the birds. In all probability the size of the tree, its location with reference to other trees, and perhaps some other factors, determined which hard maple was used lightly, and which one was used moderately or heavily.

In line with this reasoning, attention is called to the generally large percentages for "all other species" in Tables 39 and 40. Elsewhere in this study data are given to show that roosting in Ames was essentially an American elm-hard maple phenomenon. The generally more open crowns of "all other species" may have been one reason why more of these trees did not serve as roost places.

Additional evidence of the tendency for the birds to use more intensively the trees with heavier cover was obtained from the light measurements taken from October 20 to 24. The summarized data are presented in Table 40 and Figure 6. Although some of the percentages obtained were based on only a few trees, there was a definite trend for all trees to show smaller percentages with increasing degrees of use by the birds. The percentages, as expected because of loss of leaves in October, averaged considerably higher than those obtained earlier in the season. The reason for the definite trends in latter October, in contrast to the relative absence of any consistent pattern for some of the tree species earlier in the year, probably lay in the loss of cover by the trees and the consequent shifts by the birds. The birds evidently stayed in their early fall roost trees until loss of cover drove them out. In seeking out new roost places, none of which had very dense cover after mid-October, they followed their tendency to use more intensively those trees with the heavier cover.

Evening light conditions within the trees at roosting level

Light conditions and the degree of use. Observation disclosed that the roosting birds, with the exception of the robins, occupied the top one-third to one-half of the crown. Robins seemed to use mostly the central section. Because cover density light measurements beneath the trees, as described in the preceding section, were made of the light that had penetrated the entire crown and not just the portion used by the birds, it was decided to try to get a more direct indication of cover conditions at the very levels where the birds, other than robins, roosted. The time selected for these measurements was from 15 to 30 minutes before the birds arrived at the roost, until readings within the trees approached zero foot-candles. The details of the methods used are described in the section "Method of Procedure".

Several factors limited the quantity of data that were secured for this phase of the investigation. To get the most data per evening several trees which were receiving contrasting degrees of use by the birds were desired at the roosting site. Sky conditions had to be reasonably uniform to avoid wide fluctuations in light intensity readings that had nothing to do with cover conditions, and the dimensions of the trees checked had to be such that the writer could reach the roosting levels with the sectioned pole.

Table 41 shows the percentages of light at the roosting levels for the 25 trees that were measured. As can be seen in the "Summary" lines for the several species of trees, only the American elms showed a definite tendency of lower percentages with increasing degrees of roosting use.

Table 41. Evening light conditions at roosting level within the tree crowns at the time of arrival of the birds.

Species of trees	Date of light and roosting check (1952)	Degree of roosting									
		N		L		M		H		L&M&H	
		No. of trees	% of light	No. of trees	% of light	No. of trees	% of light	No. of trees	% of light	No. of trees	% of light
Elm, American	July 23					1	4.93				
	30			1	6.75	1	6.12				
				1	12.45						
	Sept. 9	1	13.41								
		1	10.17								
		1	10.56								
	Summary	3	11.38	2	9.60	2	5.52	0	—	4	7.56
Maple, Black	July 26			1	2.91	1	3.38				
						1	2.42				
						1	5.31				
	29					1	2.48	1	3.23		
						1	4.53				
	Summary	0	—	1	2.91	5	3.62	1	3.23	7	3.47
Maple, Norway	July 23	1	6.16	1	5.43	1	7.89				
	24			1	5.45	1	2.76				
	Sept. 10					1	4.35				
						1	9.10				
	16							1	6.67		
	Summary	1	6.16	2	5.44	4	6.03	1	6.67	7	5.96
Elm, Chinese	Sept. 9	1	18.76								
	16	1	14.81	1	12.60						
	Summary	2	16.78	1	12.60	0	—	0	—	1	12.60

This was entirely in agreement with the results obtained with the more conventional measurements made during noon hours beneath the trees. The hard maples showed irregular trends with no particular interpretation, but, as was expected from their noticeably denser foliage, their percentages averaged lower than for American elms. Of the three Chinese elms that were measured, the ones with the larger percentages of light getting through to the perching sites did not receive the attention of the birds. The one used lightly showed a percentage comparable to that for lightly used American elms.

Three of the Norway maples were measured again on October 24. One of these, not used by the birds but with moderate cover, gave a percentage of 37.33. Another one with very thin cover, but used lightly by the birds, permitted 42.19 per cent of the light to reach the perches; and a third tree, used moderately and with good cover, had an index of 28.16 per cent. Except for the expected low latter percentage, therefore, no trend that had any interpretation was shown for these three trees.

Light in the trees versus light under the trees. Table 42, which lists percentages of light obtained within the crowns and those obtained beneath the same trees, shows that without exception the percentages within the crowns were higher. This was as expected, for the light had to pass through only a portion of the crown on its way to the roosting positions, but had to pass through all of the crown to be measured beneath the trees. That it was not safe to try to predict the percentage within the crown from the percentages obtained on the ground, however, was suggested by the differences between the two sets of percentages. Except

Table 42. Light percentages within the crown compared with those taken beneath the trees.

Species of trees	% of light in tree Date taken (1952)	%	% of light under tree Date taken (1952)	%	% in tree minus % under tree
Elm, American	July 23	4.93	July 23	0.91	4.02
	30	6.75	9	1.48	5.27
	30	12.45	9	5.17	7.28
	30	6.12	9	0.96	5.16
	Sept. 9	13.41	Sept. 9	2.85	10.56
	9	10.17	9	1.67	8.50
	9	10.56	9	4.99	5.57
Maple, Black	July 26	2.91	July 3	0.38	2.53
	26	2.38	3	0.62	2.76
	26	2.42	3	0.33	2.09
	26	2.48	3	0.22	2.26
	26	5.31	3	1.48	3.83
	26	4.53	3	0.52	4.01
	26	3.23	3	0.25	2.98
Maple, Norway	July 23	6.16	July 23	0.42	5.74
	23	5.45	23	0.46	4.99
	23	5.43	23	0.35	5.08
	23	2.76	23	0.91	1.85
	23	7.89	23	0.27	7.62
	Sept. 9	4.35	Sept. 9	1.55	2.80
	9	9.10	9	5.29	3.81
	16	6.67	July 30	1.86	4.81
Elm, Chinese	Sept. 9	18.76	Sept. 9	1.70	17.06
	16	14.81	July 30	3.08	11.73
	16	12.60	30	6.87	5.73

for the black maples, the differences formed a rather irregular pattern (Table 42, last column). Further evidence, given in Table 43, indicated a high coefficient of correlation only for the black maples; and only for the black maples did the regression coefficient give a significant t-test (probability of less than 5 per cent), although the probability for American elms was about 6 per cent, not far from the 5 per cent mark. No reason for the wide discrepancy obtained between the two sets of light measurements for the Norway maples was apparent. Statistical tests for the Chinese elms were not included, for only three trees were involved.

Table 43. Regression of light in trees on light beneath trees.

Species of trees	No. of trees	Coeff. of corr. (r)	Regression equation	Stand. error of regression coefficient	t**
Elm, American	7	.7422	$Y = 5.76 + 1.34X$	.5385	2.4800
Maple, Black	7	.8481	$Y = 2.33 + 2.09X$	.5841	3.5806*
Maple, Norway	8	.5366	$Y = 5.10 + .63X$	.4057	1.5577

** Test of significance of the regression coefficient and/or correlation coefficient.

* Significant at $P = < .05$.

Location of roost sites

As has been mentioned, roosting in Ames occurred in two main areas from 1949 to 1952: southwest Ames, which was used extensively only during the preliminary phases of the investigation, and the northeast Ames, which had roosting birds in abundance each season that the study was in progress. Figures 7 to 10 show annual summaries of the various sites chosen by the birds during each of the four years, and Figures 11 to 16 illustrate the sites occupied at various times during one season, 1951. Blocks on which roosting occurred are shaded in red.

Figure 7, based on observations rather late in the 1949 season, before maps had been prepared to keep records adequately, probably does not show all sites used by the birds throughout the year. It does show that the birds roosted on roughly equal territories in the two study areas during the fall.

The birds' roost pattern for 1950 (Figure 8) was considerably different from that in 1949, for the birds used the northeast Ames area extensively and the southwest area very little. It must be admitted, however, that some of the roosting activity in southwest Ames could have been missed. Investigation was centered in the northeast section of the city, and observations were made there night after night. On the other hand, as soon as it was obvious that there was little activity in the southwest section, little was done there except at the times when both study areas were checked in detail. Reports of roosting in the southwest area reached the writer on several occasions, but immediate investigation seldom revealed anything beyond local activity. Nevertheless, it is possible that

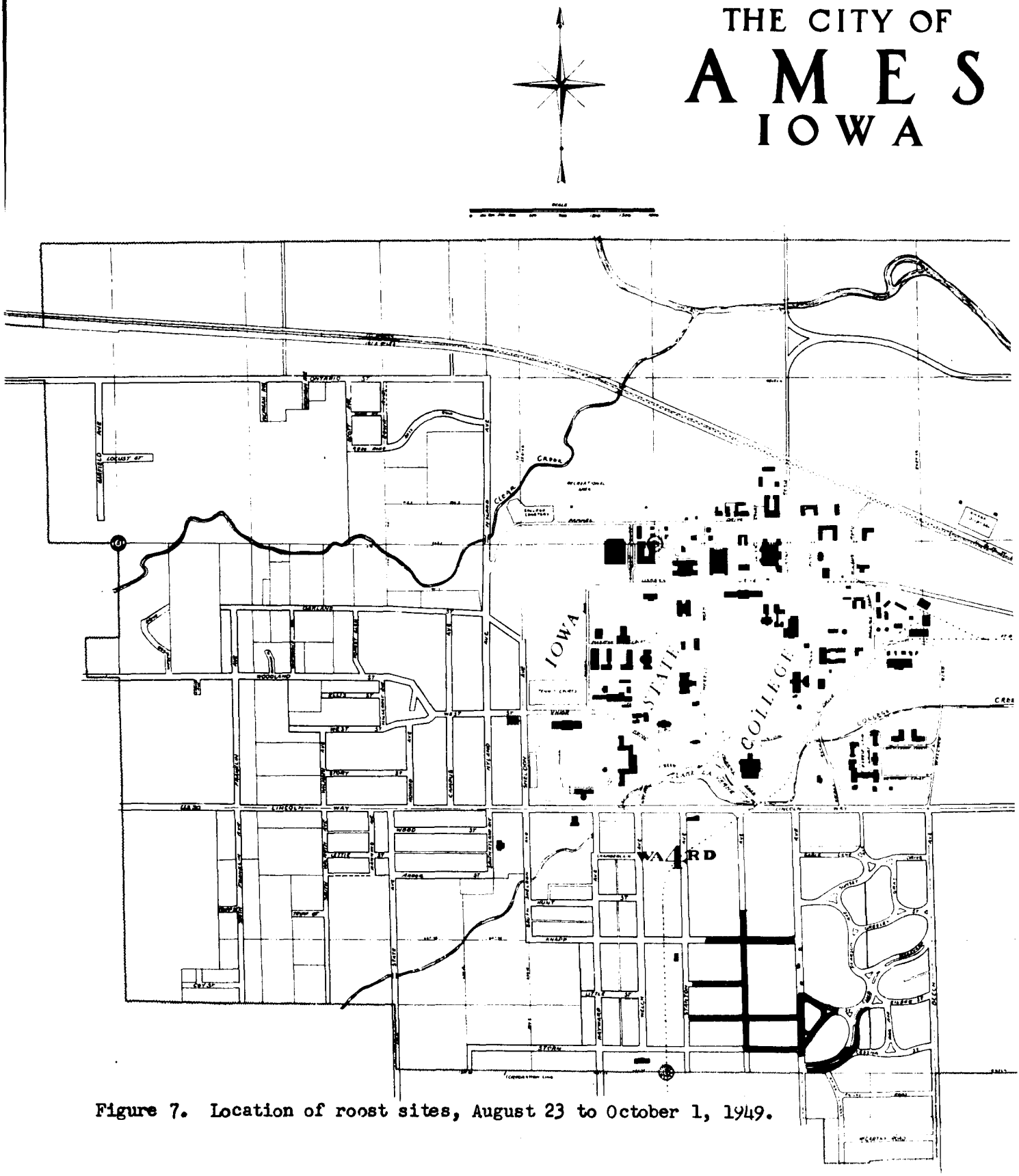
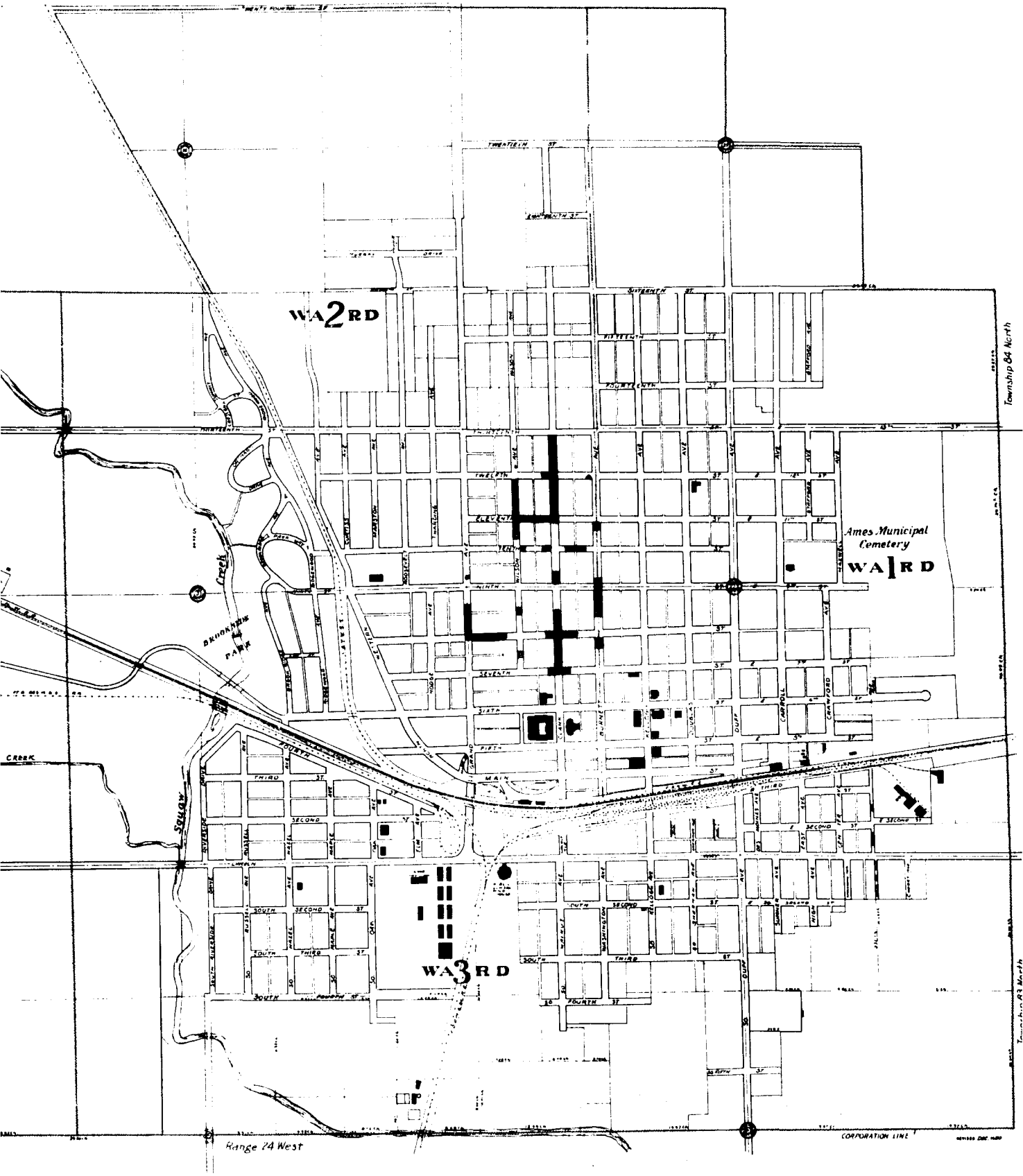


Figure 7. Location of roost sites, August 23 to October 1, 1949.


WA2RD
WA1RD
WA3RD
Ames Municipal Cemetery
Squaw Creek
Skunk River
Township 84 North
Range 24 West
CORPORATION LINE
MAIN
LINCOLN WAY
SQUAW CREEK

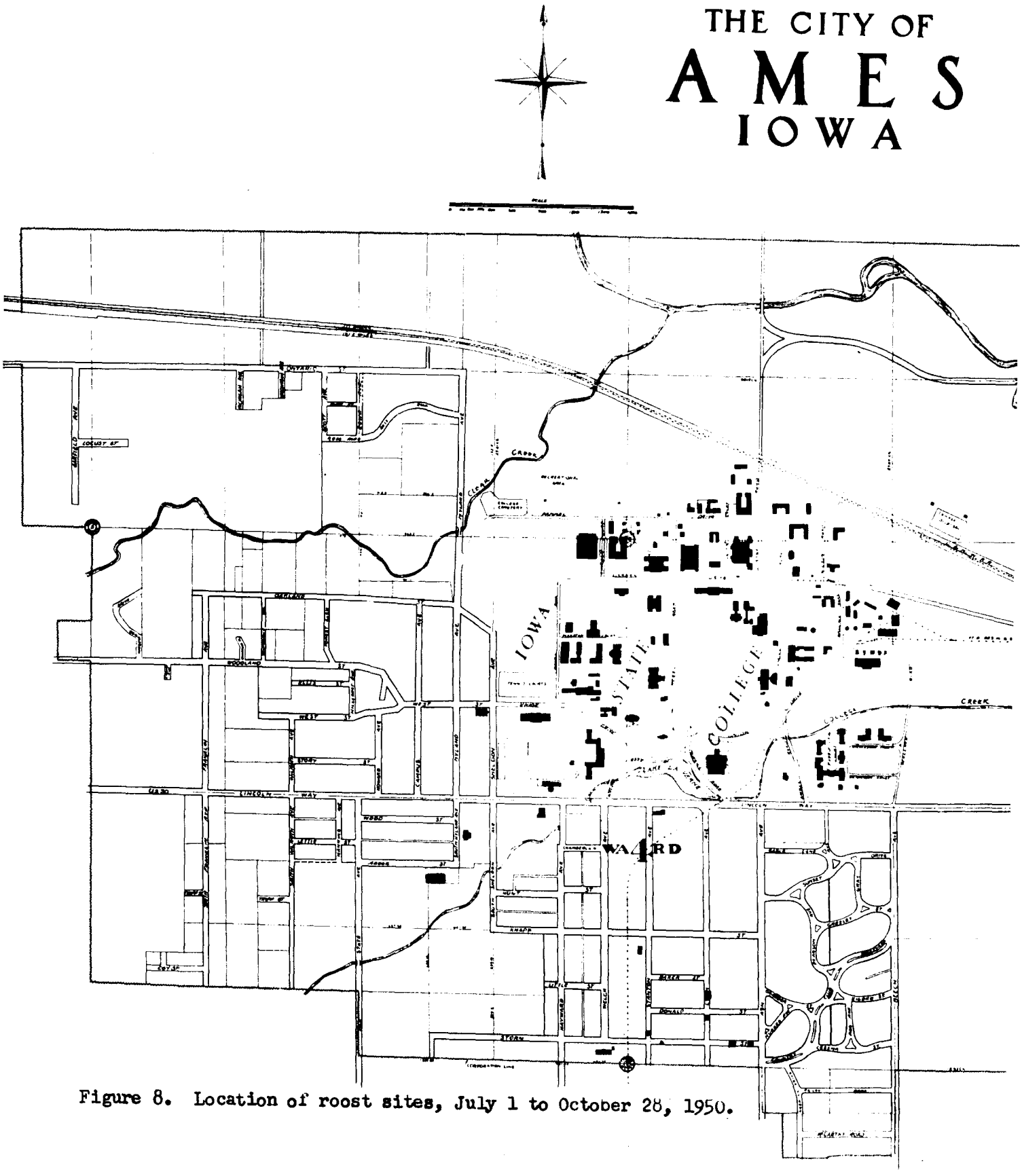
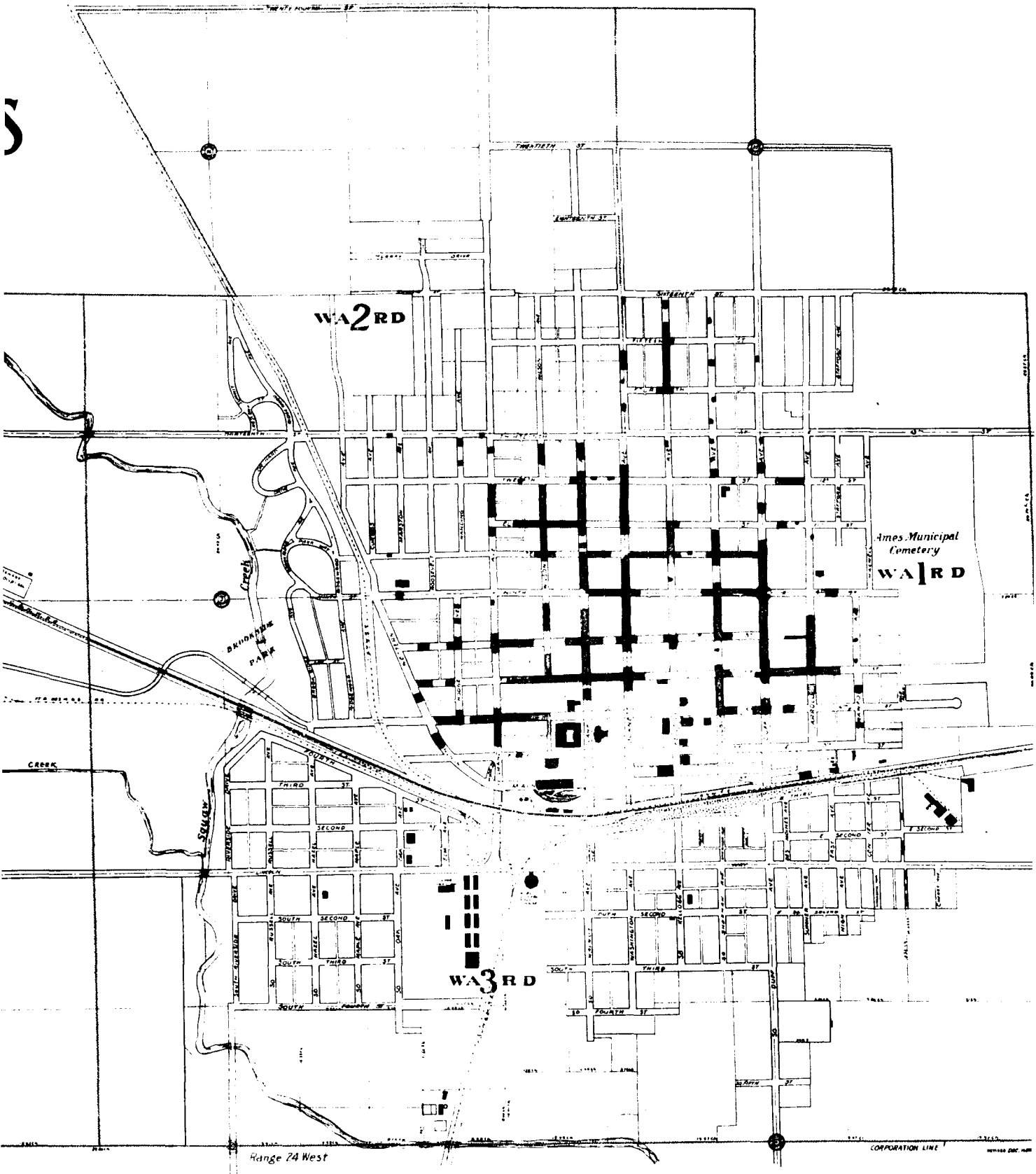


Figure 8. Location of roost sites, July 1 to October 28, 1950.


WARD 2
WARD 1
WARD 3
Ames Municipal Cemetery
Squaw Creek
CREEK
BRIDGEPARK PARK
Range 24 West
CORPORATION LINE

heavy roosting for limited periods of time may have occurred for which no direct evidence was obtained.

Although observations in 1949 were confined to the latter part of the season, and the earlier roosting activity therefore was missed, the limits of the roost sites, as shown in Figure 7, were fairly substantiated by comments from local citizens. Many people who lived near the 1950 roost sites east of Burnett Avenue and north of Thirteenth Street (Figure 8) remarked that they had not been bothered by the birds in the previous year. As can be seen by comparing Figure 8 with Figures 7, 9, and 10, the birds occupied more territory in northeast Ames in 1950 than at any time during the investigation.

The location of roost sites for 1951 is shown in Figure 9. Southwest Ames again had limited use by the birds, and it is unlikely that any serious amount of roosting in that area was missed by the writer. In the northeast Ames study area the roosting was largely confined to the western part, though the sites on Carroll Avenue and Douglas Avenue were as extensive as in the previous year. The decreased area occupied by the birds was apparently correlated with a decreased population of birds.

In Figure 10 is given the summary for 1952, but it does not show sites occupied by the birds after September 2. Drought conditions, as previously explained, prevented the use of droppings as an index of the extent of use of the trees during September and October. Therefore, periodic tours of the area were not made and maps were not plotted during that time. Direct observations of the birds during this period showed them to be present on some other city blocks in addition to those shown. On October 22, for instance, they were roosting in scattered groups on at

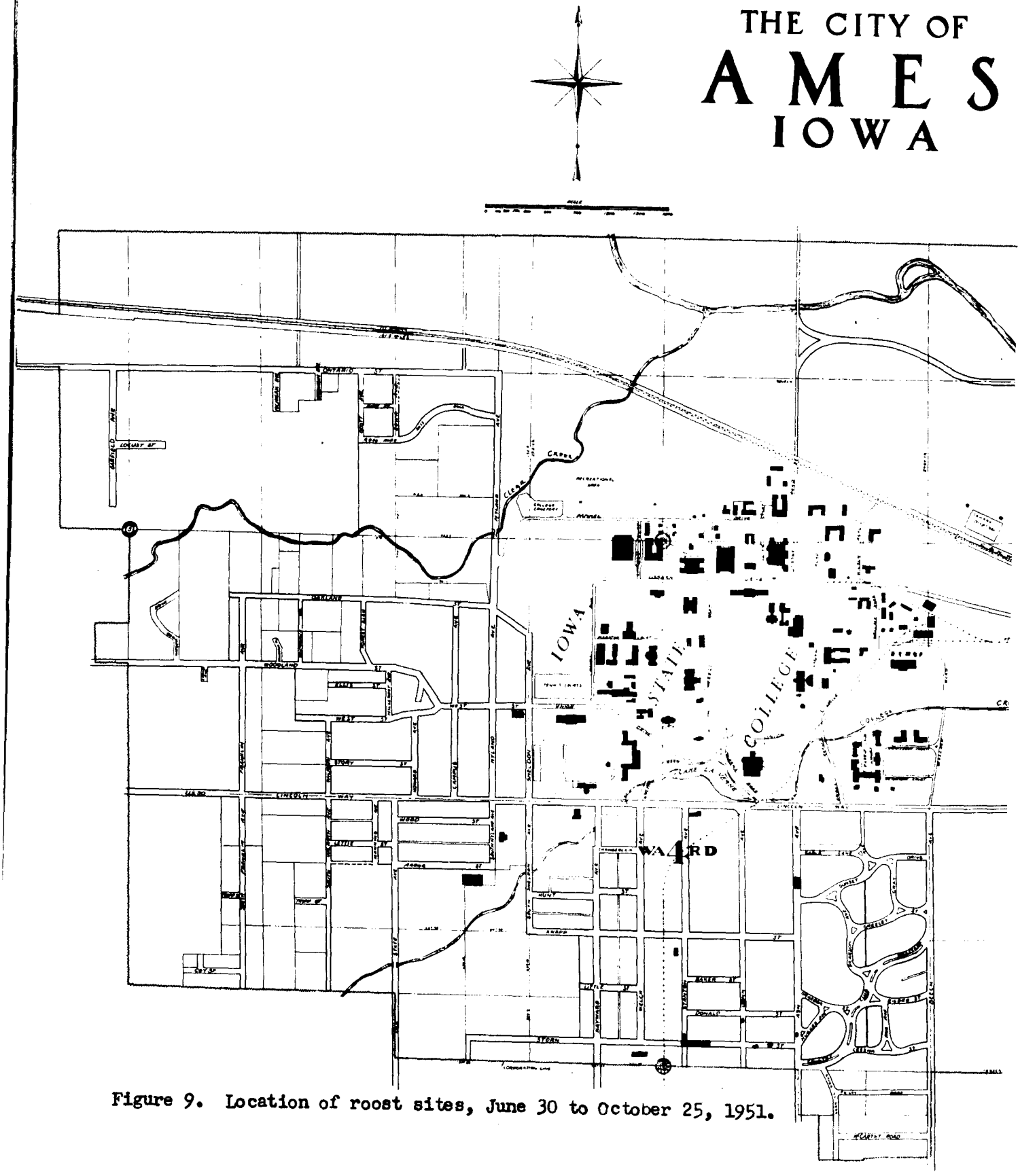
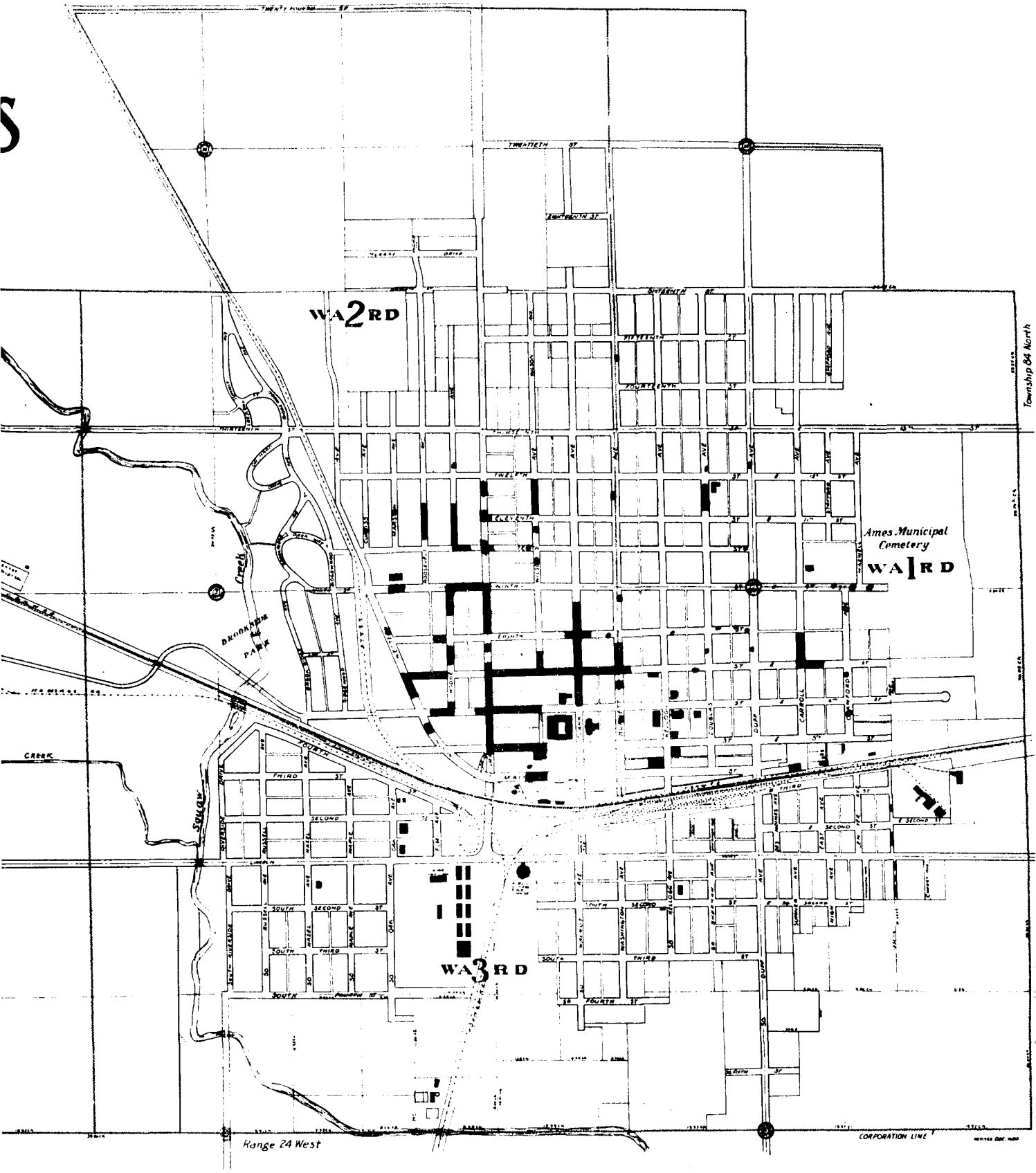


Figure 9. Location of roost sites, June 30 to October 25, 1951.


WA2RD
WA1RD
WA3RD
Ames Municipal Cemetery
Township 84 North
Range 24 West
CORPORATION LINE
Squaw Creek
Skunk River
TWENTIETH ST
NINETEENTH ST
EIGHTEENTH ST
SEVENTEENTH ST
SIXTEENTH ST
FIFTEENTH ST
FOURTEENTH ST
THIRTEENTH ST
TWELFTH ST
ELEVENTH ST
TENTH ST
NINTH ST
EIGHTH ST
SEVENTH ST
SIXTH ST
FIFTH ST
FOURTH ST
THIRD ST
SECOND ST
SOUTH FIFTH ST
SOUTH FOURTH ST
SOUTH THIRD ST
SOUTH SECOND ST
DUFF AVE
CARROLL AVE
DOUGLAS AVE
KELLOGG AVE
WASHINGTON AVE
HAZEL AVE
MAPLE AVE
RUSSELL AVE
RIVERSIDE AVE
LINCOLN WAY
MAIN ST
CLEAR CREEK
BROOKSIDE PARK

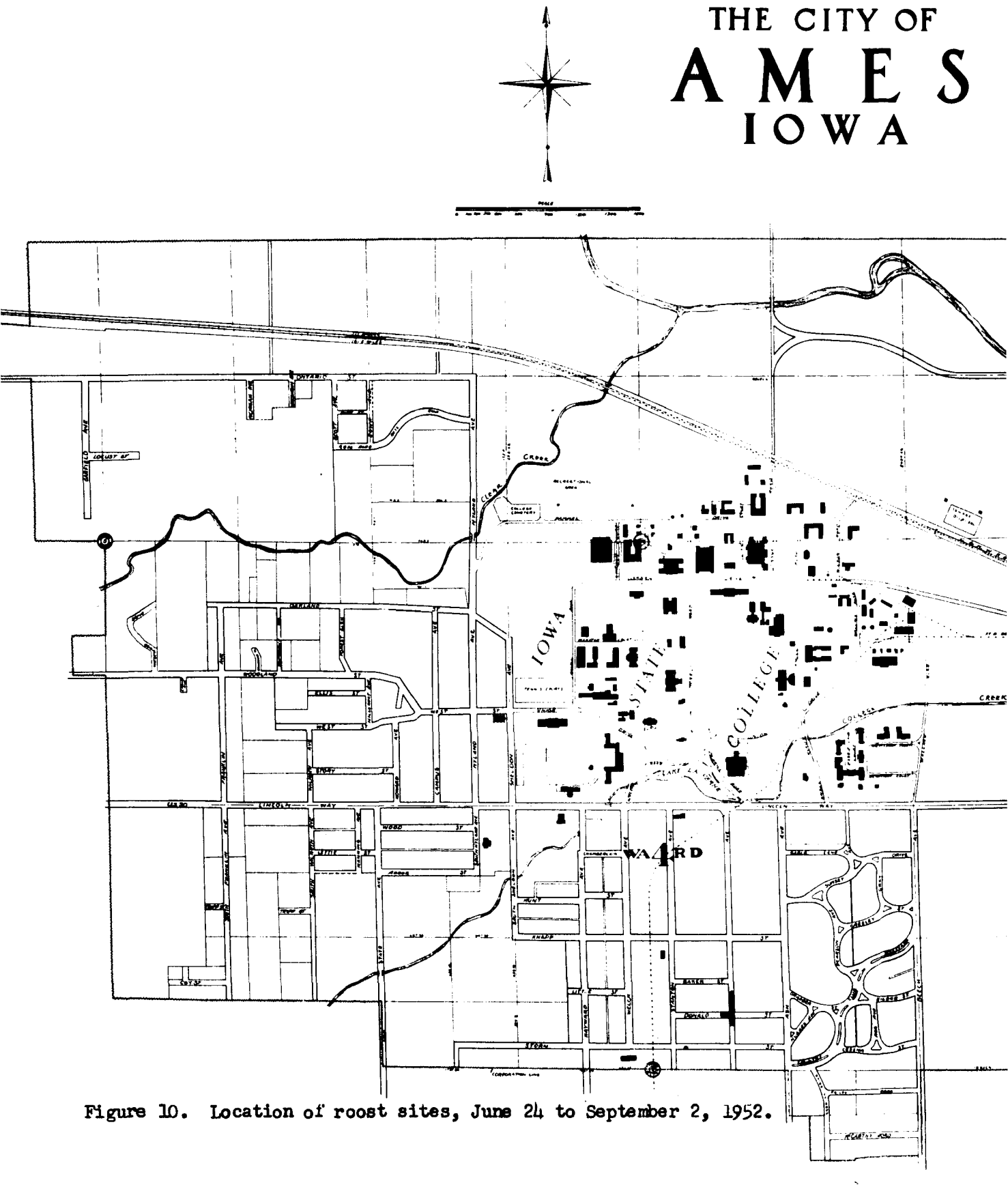
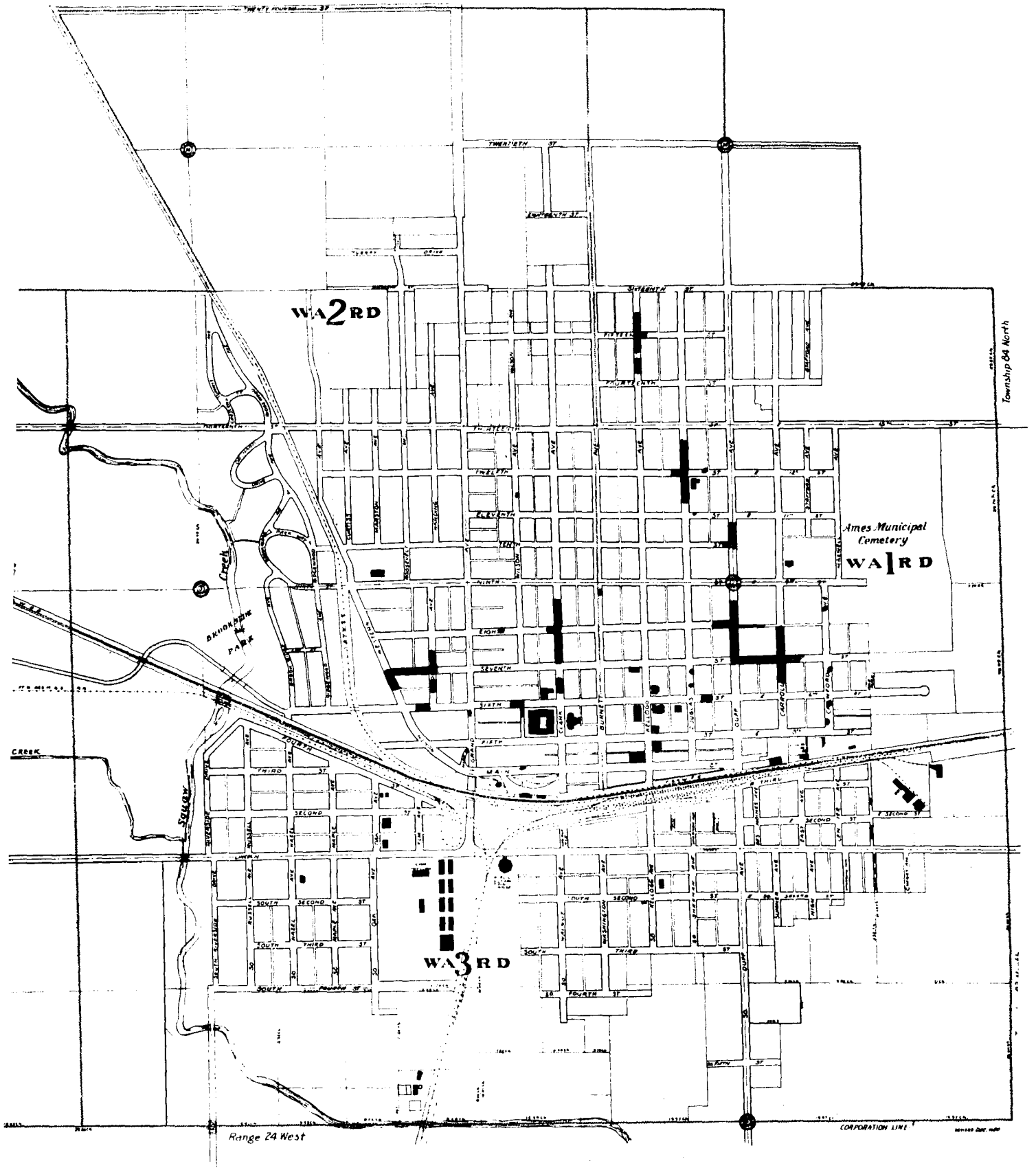


Figure 10. Location of roost sites, June 24 to September 2, 1952.


WA2RD
WA1RD
WA3RD
Ames Municipal Cemetery
Township 84 North
Range 24 West
CORPORATION LINE
Squaw Creek
Skunk River Park
TWENTIETH ST
NINETEENTH ST
EIGHTEENTH ST
SEVENTEENTH ST
THIRTEENTH
TWELFTH
ELEVENTH
NINTH
SEVENTH
SIXTH
FIFTH
FOURTH
THIRD
SECOND
LINCOLN
SOUTH
DUFF AVE
DUNNELL
CLARK
WELCH
CARROLL
HAZEL
MAPLE
WALNUT
RUSSELL
WASHINGTON
SUMMIT
HIGH
GRAND
LINCOLN WAY

least 30 city blocks at sites where foliage was still present. Most of the sites were on Grand Avenue and westward in the study area. Had a complete check been possible, it would have resulted in a map similar to Figure 9.

That the birds did not select certain sites early in the season, and then stay there during the entire summer and fall, is illustrated for 1951 in Figures 11 to 16. Roost sites on June 30, early in the roosting season, are shown by Figure 11. Several extensive roosting sites were already established, but a number of small scattered roost places were also in existence. Although most of the latter were robin roosts, some robins were noted to be roosting with the grackles at the more extensive sites at that time. Figure 12 indicates an expansion of the roost by July 16, as well as the elimination of several former sites. Small scattered roost trees still existed, some of them not the same as shown in Figure 11. By August 11 (Figure 13) the small scattered roosts had practically disappeared, and the lone trees that were in use near larger roost sites apparently took care of overflow population. Considerable shifting had occurred since July 16 , and the roost became more centered in location. Figure 14, for August 31, indicates few changes since August 11. Figures 15 and 16, for the month of October, indicate progressive tendencies for the birds to shift northwestward, though some sites remained stable until the birds migrated.

The shifting towards the northwest portion of the northeast Ames study area near the end of the roosting season was noted for several years. The American elms in that region tended to retain their foliage somewhat longer than did the same species in other parts of the city, and hence attracted the birds late in the season. Also present in that

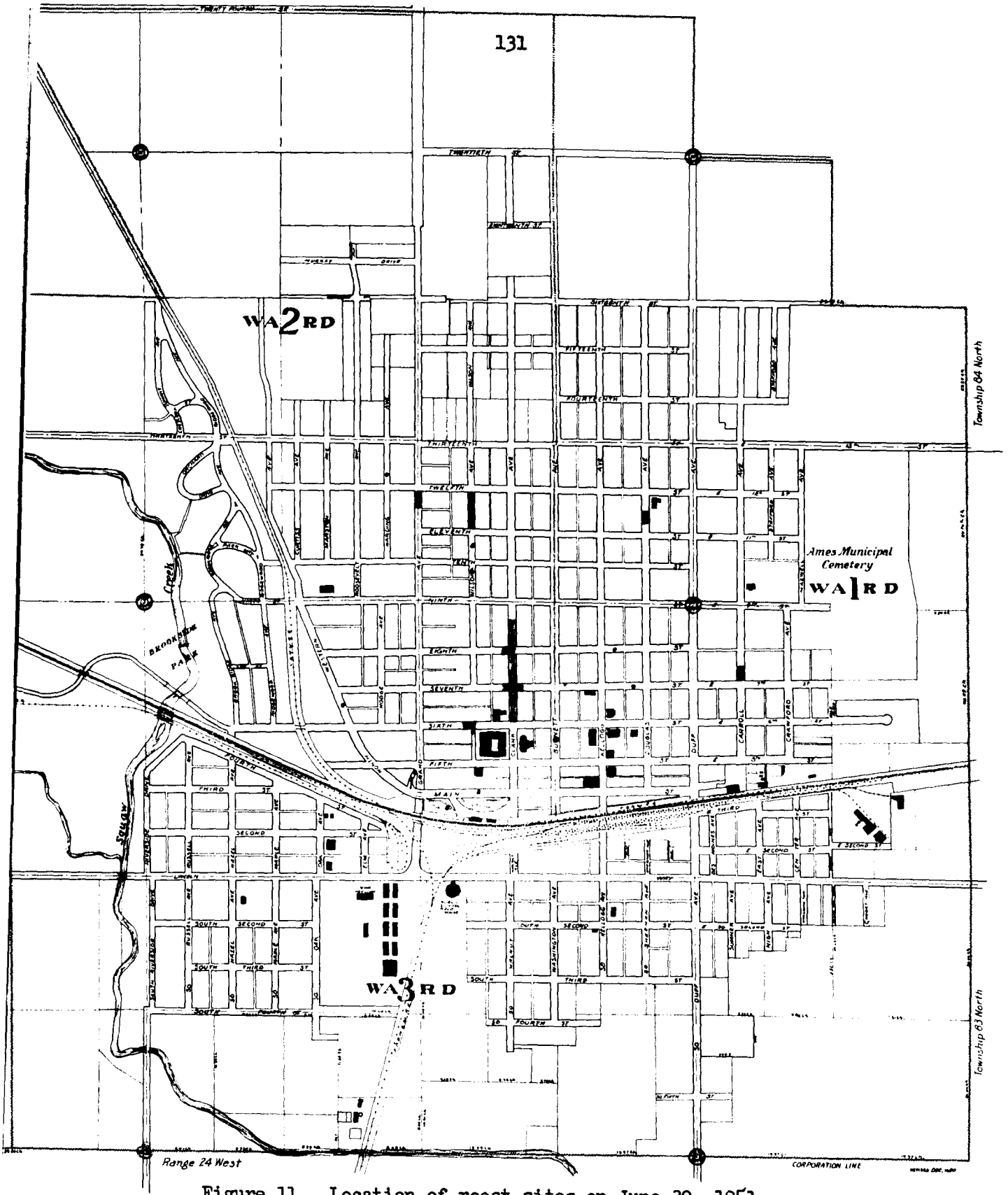


Figure 11. Location of roost sites on June 30, 1951.

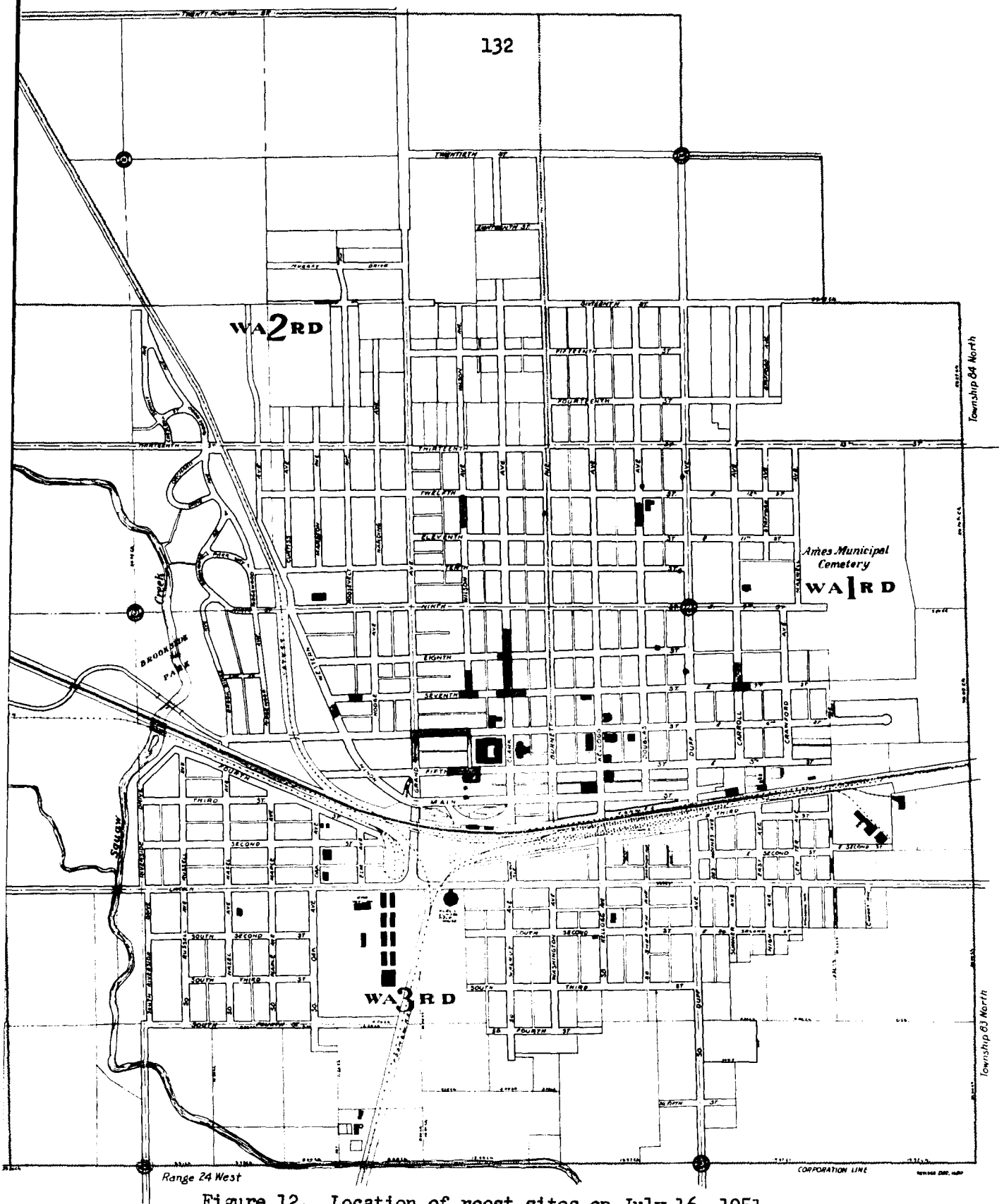


Figure 12. Location of roost sites on July 16, 1951.

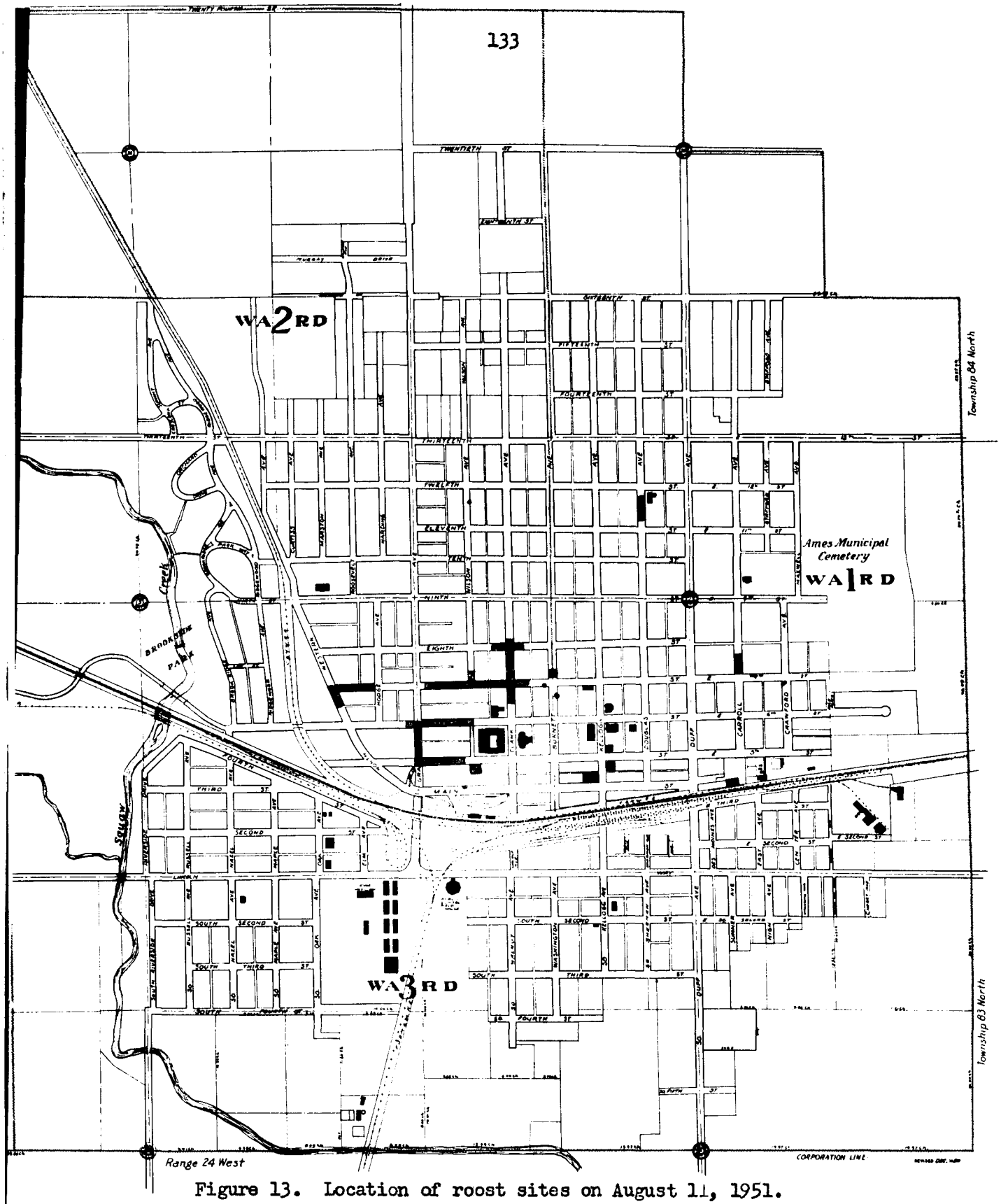


Figure 13. Location of roost sites on August 11, 1951.

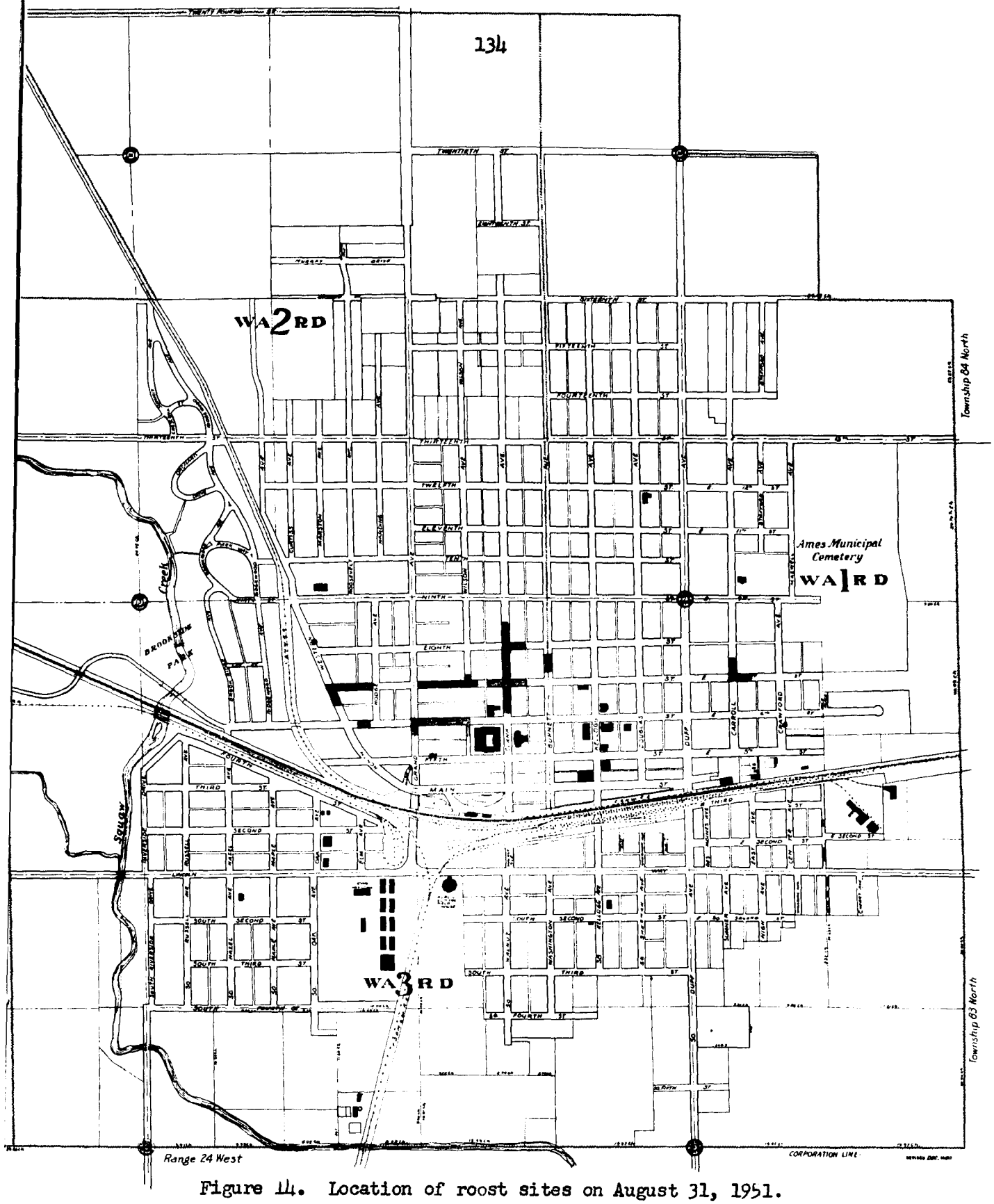


Figure 14. Location of roost sites on August 31, 1951.

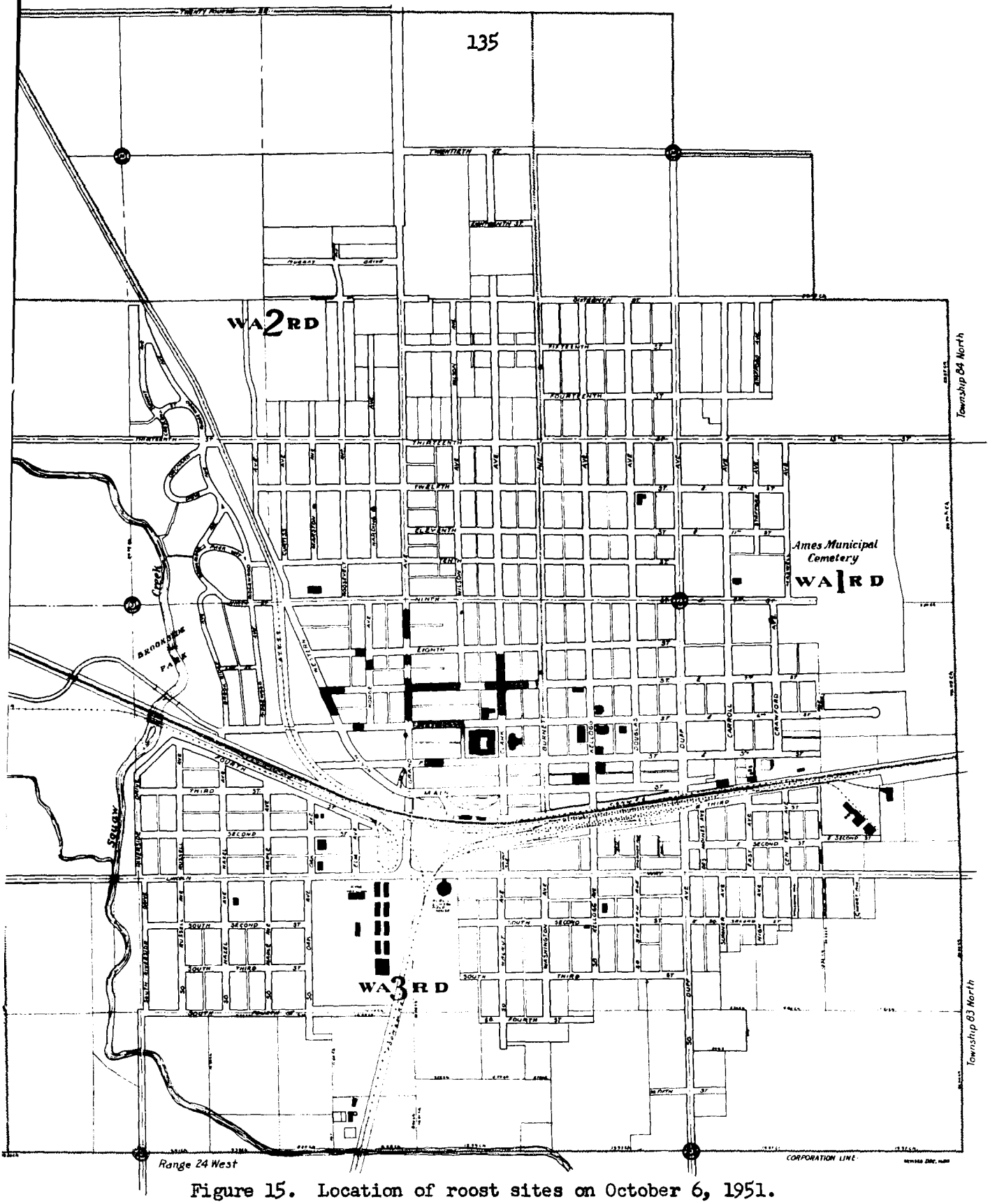


Figure 15. Location of roost sites on October 6, 1951.

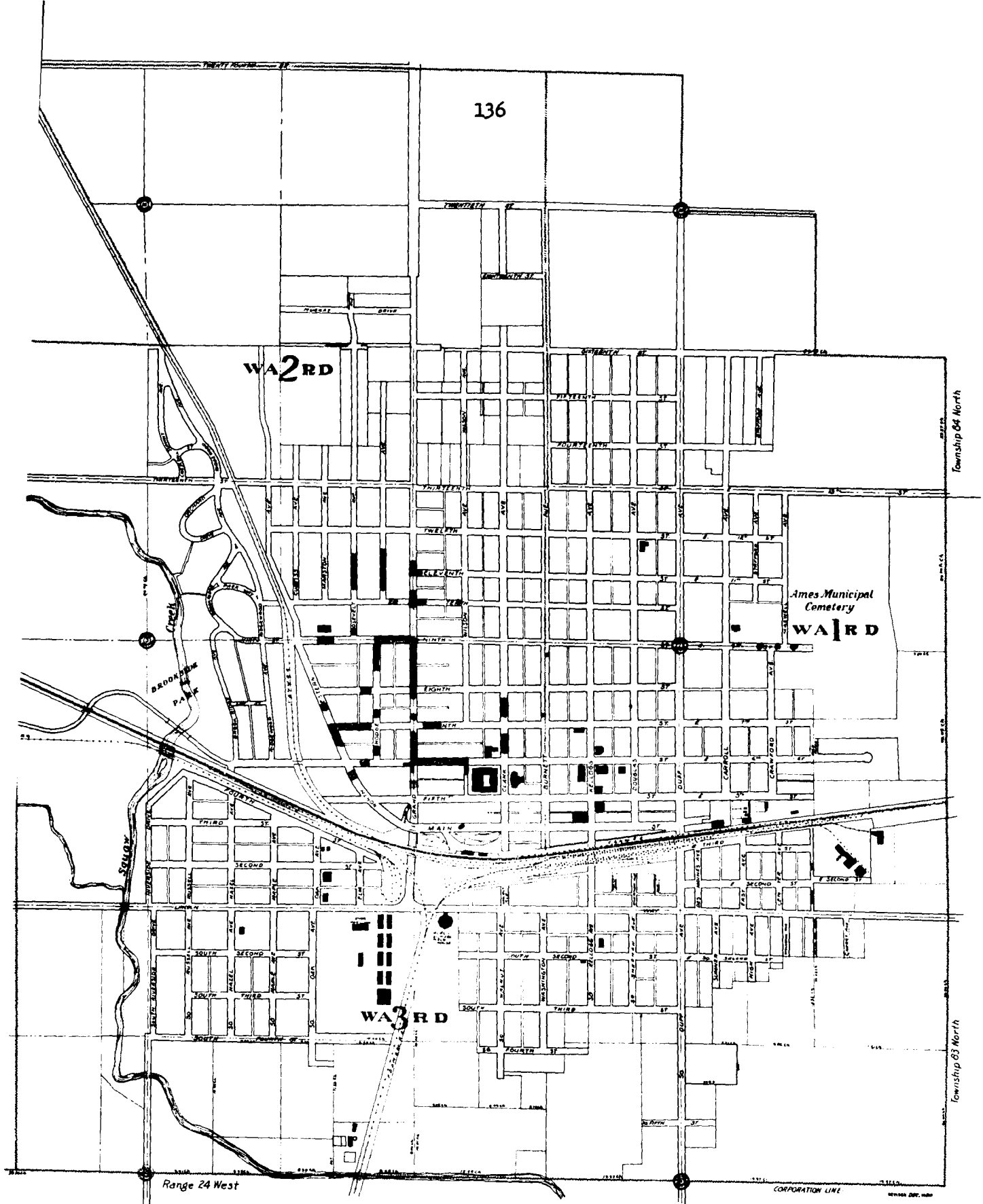


Figure 16. Location of roost sites on October 25, 1951.

part of the city were a number of Chinese elms which provided suitable cover at a time when nearby trees, including the American elms, were already bare. When these trees finally lost their leaves each year, gregarious roosting was no longer seen in Ames.

Efforts at roost control in Ames

At only one roost site in Ames, to the knowledge of the writer, did the local residents react with any degree of favor toward the roosting birds. These people seemed to enjoy the phenomenon of hundreds of birds in their trees each night. At all other places the birds were not welcomed at all, but at the best were grudgingly tolerated. A number of people tried various expedients to drive the birds away, but such efforts were often of a desultory nature and were usually not carried on with any necessary degree of persistence.

Efforts at control noted in Ames can be classified under five headings: sudden loud noises, flashlights and spotlights, guns, tree removal, and miscellaneous. All endeavors were by individual citizens, and no organized attempts by the community were tried during the investigation.

Perhaps the most common method used by the people to try to expel the roosting birds, or to prevent them from settling in the trees, was to make loud noises. One man, who was quite persistent in his efforts, in 1949 beat upon the sidewalk with a snow shovel at a time when the flight was crossing his premises. Although it was difficult to evaluate the results, the birds were never seen in the tall American elms in front of his home on Wilson Avenue except to stop at times when he was not active. These results were obtained in spite of a major roost site with a similar stand

of trees only a block away.

That noise was of some value at times was also indicated in 1949 at the "similar stand of trees" in the 1200-block on Clark Avenue referred to above. After the birds had established themselves, one of the ladies in the block beat with a board upon a cement railing on her porch. In a matter of only a few days the bird population in the immediate neighborhood seemed to decrease, but lack of persistence may have prevented abandonment. The noise did not cause the birds to fly very far, for they usually lit in trees less than a block away, and when noise-making was stopped some of the birds invariably returned to the original site.

When a number of people in a roost block on Sixth Street resorted to noise-making in 1951, mostly by slapping boards together, the only results seemed to be to drive the birds back and forth early in the evening. Later, after the birds had settled in the trees for the night, the noise had little if any effect. What the effect might have been had efforts been made night after night is not known, for only one man in the block was noted active for a number of evenings.

A bicycle horn inserted in a washing machine agitator provided a lady on Carroll Avenue with a noise-maker of ear-splitting potential. With it she claimed to have cleared the American elm in her back yard for two successive years. She may well have been correct, but the tree was a lone tree, one that seemed to be roosting overflow population. A major roost site, composed of a close grouping of black maples, was not more than 150 feet away, and birds that were seen to leave her tree flew toward the major roost center. In spite of her nearness to the black maples, her sounds had no visible effects upon the birds there.

A more technical approach to noise-making was tried in 1952 on Carroll Avenue. Equipped with an electronic oscillator, one of the residents experimented with supersonic frequencies as well as with audible sounds of very high pitch. His only results were vigorous complaints from his neighbors whenever he adjusted his instrument for sonic ranges. Brand and Kellogg (1939) showed that starlings apparently did not respond to frequencies above 15,000 vibrations per second, and the above experiment suggested that perhaps bronzed grackles and other occupants of the roost also were not receptive of high frequency sounds.

In general it was observed that noises had noticeable effects, if any, only during the early parts of the evening. Although many birds stayed on their perches in spite of noises, at least some of them usually flew from the trees near which sudden loud sounds were made. Later, when the noise-making subsided, a number of birds invariably returned. Noises ordinarily had little effect after the birds had settled for the night, especially if they had been disturbed considerably earlier in the evening.

Second only to loud noise, beams of light from flashlights or other devices were the most commonly tried expedient to break up a roost site. Usually the beams of light were combined with noise-making, but several people used only the lights. As was true for noises, beams of light produced very indefinite results. At only one site, to the writer's knowledge, was there any persistance in the efforts, and then it was futile because of the weak beams caused by obviously worn out dry cells.

At several places during 1952 bright beams of light were noted to be disturbing stimuli before the birds were settled for the night. Later in the evening the only responses to the light were some calls from the

birds, and later still there were no responses at all. At each of these places the birds had been subjected to the beams off and on all evening, and while it was true that some birds had left the trees in question, apparently most of them had remained.

Combinations of loud noise and light beams were noted a number of times with varying degrees of success. The birds thinned noticeably at the south end of the 700-block on Duff Avenue, for instance, after one of the citizens persistently used a combination of bright flashlight beams and the shooting of caps. The results were accomplished in about three weeks and with $10.00 worth of caps. No effects were noted on the roost at the north end of the block. In 1952 the birds left the 700-block of Hodge Avenue, after roosting there only four or five nights, seemingly because several people in the block disturbed them for several nights with noise and flashlight beams.

Very local results, which cleared only a few trees of roosting birds, were also observed. In 1949 a combination of gravel thrown into the trees, flashlight, and very bright spotlight, caused the roosting birds to leave several Norway maple trees on Lynn Avenue. Nevertheless, the birds did not fly far off, and some of them went no farther than to trees across the street. In 1951 some children, who employed boards slapped together and a bright flashlight beam, emptied several black maples of the birds in the 600-block on Seventh Street. Not disturbed during the early part of the evening, the birds responded wildly to the children's treatment which came just as the birds had quieted for the night.

Shooting at the birds with shotguns, an expedient tried at various places in the two study areas, had no noticeable permanent effects as

it was usually performed. Most people who resorted to guns fired only a shot or two on some one evening and then ceased in their efforts. At places where shooting was persistent, on the other hand, especially where it was done early in the evening, local clearing of roost trees resulted.

That shooting, to be effective, had to be done before the birds settled for the night, was observed on Clark Avenue in late September, 1949. One of the local residents, who used a 410-gauge shotgun, one evening fired a number of the shells at the birds in his trees from the time they arrived until they had settled for the night. The earlier shots invariably caused the birds to fly wildly about, though few casualties were inflicted, but as the evening wore on the tendency to fly decreased. The last shot for the evening was fired into the tree when the birds were more or less settled. Though it killed two grackles and one starling, no birds were seen to leave the tree. Similar shooting earlier in the month was reported to have given similar results. Since the shooting was not repeated on succeeding days, no permanent results were noted.

That shooting sometimes was successful even in a relatively short time was observed in August, 1952. A catalpa grove at the west edge of the Maney Memorial Park, outside of the regular study areas, was cleared of its estimated 20,000 birds in only three nights of shooting with a 12-gauge shotgun and with only 17 shells. Shooting the first night was performed rather late, after the birds had begun to settle, and had no visible results. Shots fired from the time the birds arrived on the other two nights gave complete success. One man did all the shooting, and less than 10 birds were killed. It must be noted, however, that several boys with compressed air guns had shot in the grove sporadically for a

week or more prior to the shotgun attack, and may have been a factor in causing the birds to move so quickly.

Shooting combined with strong light beams and a great deal of noise-making on wash tubs, boards, and other devices may have caused the birds on the 500-block on Grand Avenue to move to other sites in both 1950 and 1951. Efforts were said to have been most successful when tried early in the evening.

Several people in Ames succeeded in clearing the trees on their premises of the roosting birds by shooting, but when their efforts ceased the birds returned. Local shooting in the 900-block on Burnett Avenue in 1949, though sporadic, could well have been the cause for the bird population thinning there, and even an air rifle, persistently used, seemed to have such results at the corner of Eighth Street and Burnett Avenue in 1950.

Though more strictly a noise-making method than shooting, a method used near Eighth Street and Duff Avenue during September, 1952, can well be mentioned here. Firecrackers, which were tied to a piece of wood of manageable size, were ignited and tossed into the trees among the birds where they exploded. With no known casualties, three nights of such efforts by a man and his wife succeeded in moving thousands of birds that had roosted there for weeks. New roost sites were established by the birds several blocks away. After a few weeks some of the birds returned to the former site, but they did not begin to approach their former numbers there.

One of the miscellaneous methods used in trying to break up roost sites was pounding on the trees with an axe. Tried on Carroll Avenue

and Lynn Avenue, it succeeded in more damage to trees than in permanent success with the birds. Streams of water from garden hoses were also tried on several occasions, but were not seen to move a single bird. The dense foliage of the hard maples, on which the water was directed, permitted little water to reach the birds. Hitting branches with a long pole caused a few birds to leave the trees where tried, but it was never carried on persistently enough to get lasting results. Chemical smokers, such as formerly used in driving animals from dens, were tried on a still evening beneath a hard maple on Kellogg Avenue. It was reported that many birds left the tree in response to the smoke and that the tree had a noticeably smaller roosting population for several nights following, but that later the birds returned in numbers.

The most drastic of control measures, the removal of the shade trees, was resorted to at several locations in Ames. Several large hard maples in the 1200-block on Clark Avenue, and two large American elms in the 600-block on Sixth Street, were cut down because of their use by the birds, and the roosting of the birds was partly responsible for the removal of three large American elms in the 400-block on Seventh Street. During the winter of 1952 to 1953, after the present investigation had been completed, several of the black maples in the 700-block on Carroll Avenue, which had been heavy centers of roosting for at least three years, were removed to get rid of the birds.

The Evening Flights

Introductory remarks

During the four years that observations were made on the characteristics of the roost in Ames, the evening flights to the roost were also studied. As explained in the section, "Method of Procedure", efforts were made to get population estimates of the birds while in flight, to observe their behavior while on their way to the roost, and to discover whether or not readily measurable weather phenomena had any noticeable effects on their behavior.

Although some observations of the flights were made beyond the city limits of Ames, intensive study was limited to places within a few blocks of the northeast study area. Here the birds were on the last stage of their daily trip to the roost, and the flights were fully formed or organized. Little was seen of the manner in which smaller flocks converged to form larger flocks, as described by Jones (1897) and others.

The birds were observed at such places where a reasonably broad expance of open sky was available, and where experience showed that most of the flight was visible.

General characteristics

Experience soon showed that several flights of birds came to the Ames roost each evening. For purposes of the present investigation they were named according to the direction from which they entered the northeast Ames study area. Figure 17, which depicts the flights as broad, red arrows, indicates that there were four flights: southwest, north,

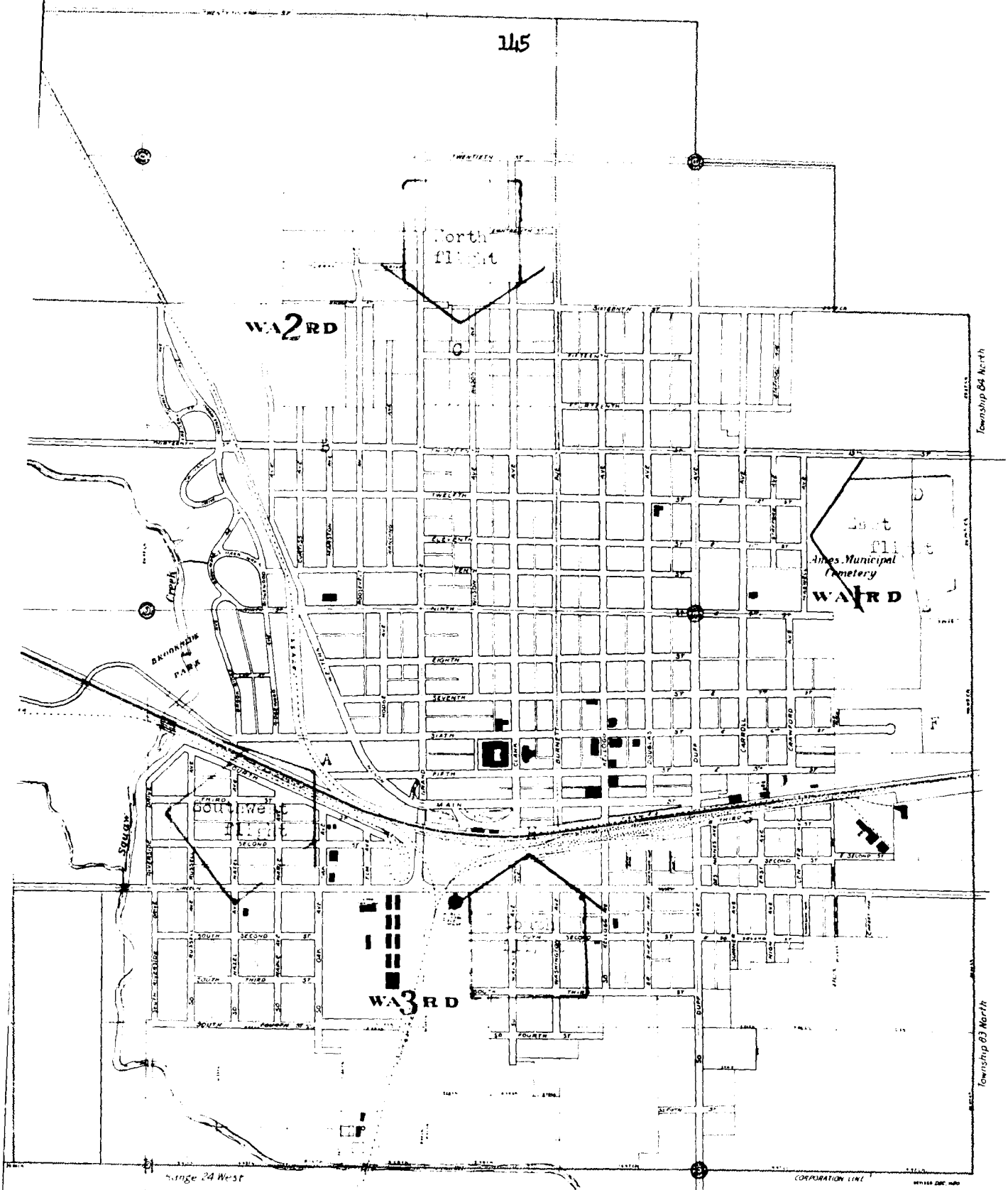


Figure 17. Location of the flights and the points of observation.

east, and south. Each seemed to be an independent unit, and each had some characteristics of its own. Figure 17 also shows, in red letters, the location of the main points from which the flights were observed.

The main portion of southwest flight usually entered the northeast Ames study area approximately at the level of Sixth Street, although it shifted both northwestward and southeastward somewhat on different days. As the season advanced there was a decided tendency to shift about a block northwestward, a move that was correlated with the shifts in roosting sites. The birds then crossed the Sixth Street overpass and entered the study area approximately at Seventh Street. On most evenings, regardless of the time of the year, the flight line ordinarily was about two to three city blocks in breadth, and was never seen to be less than a block wide. On occasion there were two or three subdivisions of the flight, with the several strings of birds 200 to 300 feet apart. Of the four main flights that came to Ames daily, this one was the most stable. It varied relatively little in location, and did not change materially in numbers of birds present until the last year of the investigation. In that year, 1952, most of the birds of this flight stopped to roost at the catalpa grove just west of the Maney Memorial Park, near the city limits of Ames, and did not continue to the northeast study area.

Many of the birds of the southwest flight used the trees along Russell, Hazel, and Maple Avenues, and the trees along Second, Third, and Fourth Streets (under the base of the red arrow in Figure 17) as a final stopping place before flying to the roost. Not only was this a stopping place, but it was also a final gathering place for several

populations of birds, for on a number of evenings a group of birds from the northwest joined the other birds here.

The southwest flight was observed from point "A" in Figure 17, between the west end of Fifth Street and the Sixth Street overpass. The broad expanse of sky available here made observations relatively easy. Only those birds that came too far northwestward were completely obscured by trees. Since the birds did shift their flight lines to a degree, it must be admitted that some birds probably were missed at times, and were not included in the population estimates.

Of a somewhat different character, the north flight tended to enter Ames near Grand Avenue. From 1949 to late July, 1951, the flight extended eastward to Burnett Avenue, a distance of three city blocks, but extended very little west of Grand Avenue. About the last week in July, 1951, a noticeable change occurred. Over one-fourth of the birds then entered Ames west of Grand Avenue, the bulk of which flew between Marston Avenue and Harding Avenue. Because the remaining three-fourths of the birds continued their evening flights as in the past, the entire north flight then extended from Curtiss Avenue on the west to Burnett Avenue on the east, a distance of seven city blocks. This broad path was maintained for the remainder of 1951, and was used throughout 1952. Jones (1897), who mentioned changes in the direction of flight lines, believed they were related to the location of foraging grounds and to the location of other roosts. Whether or not this was true at Ames was not investigated.

A number of the taller trees near Grand Avenue, just north of Fifteenth Street, served many of the birds as final stopping places, but no evidence of convergence of sub-flight lines was ever seen here.

The corner of Fifteenth Street and Wilson Avenue, point "C" of Figure 17, was usually used to observe the north flight. Here the birds were visible on an east-west line from Harding Avenue to Burnett Avenue, although the birds at the western extreme were often within sight for only a very few seconds before houses obscured them from view. After the north flight had broadened its path, the western-most birds were observed from the corner of Thirteenth Street and Marston Avenue, point "B" in Figure 17. Here the birds were observable from Ridgewood Avenue on the west to Harding Avenue on the east.

From the standpoint of the location of the flight line, the east flight proved to be highly erratic. Figure 17 shows a typical locality where the birds entered the city, though often they were much farther south or north. Sometimes they were so far north as to be hidden from view at point "D" where most of the observations were made. It proved discouraging to gather data on this flight, for as often as not the flights did not appear at all. At other times several streams of birds were present at the same time, one of which came to Ames about the level of Seventh Street, and the other between Ninth Street and Thirteenth Street, or still farther north. As a consequence the entire east flight spread over a path which extended from about Fifth Street to well beyond Sixteenth Street, though never over this entire range at one time. On several occasions the birds entered northeast Ames at the corner of Burnett Avenue and Twentieth Street. Potter (1912) thought that flight lines were permanent for each roost. The flight lines from the east, at Ames, were certainly only relatively so.

Trees along the Skunk River were common final gathering places,

though some of the birds stopped in the trees of the Ames Municipal Cemetery before going to the roost area. On several occasions hundreds of grackles and starlings stopped to feed in the fields immediately east of the observer, where they stayed only a few minutes before going to Ames.

The east flight was easily watched just east of the Ames Municipal Cemetery. Although most observations were made about the level of Twelfth Street, at point "D" in Figure 17, the birds were also watched farther south at the levels of Ninth Street and Sixth Street, at points "E" and "F", respectively. Point "D" was favored because access to it was easier, and because experience showed that the birds tended to come near there more frequently than to the other two places.

The last of the four major flights shown in Figure 17, the south flight, tended to center its entry into northeast Ames along Clark Avenue, on a direct line to the roost sites on Clark Avenue and adjacent areas. As the season advanced, sizeable proportions of this flight flew farther east, and some of the birds then came into Ames as far east as near Center Street. This eastward shift was correlated with the growth of the roost sites on Carroll Avenue and Duff Avenue, and caused the south flight to spread over an area which extended from the level of Burnett Avenue on the west to Center Street on the east. In late summer and fall the entire path of seven blocks was sometimes in use, with the birds concentrated in lines just south of Clark Avenue, between Kellogg Avenue and Duff Avenue, and near Center Street. Stopping places were in trees in the southeastern part of the city, and for a few brief periods of time the

trees near the Evangelical United Brethren Church, on South Second Street, even became roost places.

Excellent views were had of the in-coming flight as it crossed the Chicago and Northwestern Railway tracks. Nearly all data for this group of birds were gathered just east of Clark Avenue at point "H" in Figure 17. Here all birds that came from the south could be seen, though the birds east of Duff Avenue were too far away for species to be identified positively when light conditions were poor. Various places along the railroad tracks were also used to observe the flight, with the eastern-most point at "G" near East Avenue.

In summary, three of the four flights that entered northeast Ames had very broad fronts, and only the southwest flight had a relatively narrow one. On none of the flights were the birds evenly distributed along the entire breadth of the flight line, for concentrations occurred at fairly definite places.

Estimates of the populations

Problems of estimating the bird populations. During the course of the investigation people in the roost area frequently queried the writer about the numbers of birds present. Many of the local residents were quite ready with their own suggestions, and frequently postulated "millions". To get some reasonable estimate of the total bird population was one of the motives for watching the flights repeatedly. As is outlined in the section, "Method of Procedure", the birds in small flocks were counted, but the populations in larger flocks had to be estimated by five's, 10's or 100's. A single-unit mechanical tally

counter was used to keep track of the numbers in 1950, and a multiple-unit counter was used in 1951 and 1952.

A number of problems were encountered in trying to get population estimates, and no one method used proved to be entirely satisfactory. The multiple counter, for example, proved very useful in getting records every 10 minutes of the total numbers of the several species of birds that had passed the observer. Yet it was of little value in keeping records of the sizes of the flocks.

When efforts were made to keep track of the individual flocks, and to record estimates of their sizes, frequently several flocks slipped by while the observer recorded his data. The problem of what to call a flock was also always present, and arbitrary decisions often had to be made in an instant when many birds were in the line of vision. Long strings of grackles, with minor breaks in the lines, were classified as single flocks, but it was purely subjective as to how much of a break had to occur before the data were recorded as several flocks.

When the birds came as fast as 1,000 per minute, the concept of flocks meant little. Then the writer had all he could do just to get a record of the total numbers of birds. Since four species of birds, bronzed grackles, starlings, cowbirds, and robins, were present in each of the flights, not only was it necessary to estimate numbers, but it was essential to identify the birds and then record the numbers in proper places on the field record sheets. When the flocks were mixtures of the several species, it was often impossible to estimate fast enough, and then write rapidly enough, so that hundreds of birds were not missed while the numbers were recorded.

As a consequence of the difficulties encountered whenever efforts were made to get data on flock size, sometimes as much as three-fourths of the flight population was simply listed as "birds".

The accuracy with which the writer estimated the numbers of birds in small flocks was checked at a spring roost in 1952. On five evenings a helper counted the birds in a number of flocks while the writer tried to estimate them at speeds which were necessary for the flights in the summer. Twelve flocks, that ranged in size from 23 to 46 birds, were estimated with 94.5 per cent accuracy; and 13 flocks, with nine to 19 birds, were estimated within 0.5 per cent. The tendency was to underestimate, although there were a number of correct numbers as well as some overestimates. No satisfactory method was discovered to check the estimates made of the large flocks observed in the summer, but since estimates of the same flight on successive days were often quite similar, when weather conditions seemed to be alike, it was felt safe to assume that the numbers obtained were at least relatively comparable.

Numbers of birds coming to Ames. Table 44 summarizes the estimated total numbers of bronzed grackles, starlings, cowbirds, and robins that came to Ames on the various flights during 1950, 1951, and 1952. Because of the difficulties inherent in counting thousands of birds, the totals obtained were probably too low, but since the same methods of estimating were used throughout, any errors were assumed to be of the same order of magnitude.

As Table 44 shows, the numbers varied considerably with the season and sometimes also on a day to day basis. In general, the flights began with small total numbers in late June, increased until maximum populations

Table 44. Observed numbers of birds coming to Ames.

Year & month	Flights							
	Southwest		South		North		East	
	Day of month	Number	Day of month	Number	Day of month	Number	Day of month	Number
1950								
June			29	1,505				
July	13	5,322	11	1,279	25	10,633	21	248
	14	5,344	20	1,662	27	10,509		
	19	12,640			28	10,500		
Aug.	9	8,906	7	4,989	12	14,453	15	9,255
							17	2,137
Sept.	4	16,436	8	1,578	6	26,581	7	186
	5	11,884	14	2,716	25	21,878	30	21,401
	20	18,542			26	26,594		
Oct.	13	2,907						
	21	1,720						
1951								
June	21	259	20	221	25	806		
July	10	5,133	12	1,318	18	3,511		
	11	6,806	14	1,264	19	3,952		
	31	10,964	17	994	20	4,263		
					21	3,155		
					22	3,370		
					23	3,730		
					24	4,121		
					25	5,399		
					26	3,710		
					30	2,914		
Aug.	17	10,500	1	2,481	2	1,862	6	5,283
	18	14,446	3	3,262	13	1,718	7	9,696
	19	14,027	27	432			28	1,726
	20	22,557						
	21	20,205						
	22	16,468						
	23	20,800						
	24	26,729						
	25	24,531						

Table 44. (Continued)

Year & month	Flights							
	Southwest		South		North		East	
	Day of month	Number	Day of month	Number	Day of month	Number	Day of month	Number
1951 (cont'd)								
Sept.	11	19,700	18	20,279	6	25,444	19	285
					8	7,093		
					20	1,347		
					24	6,326		
Oct.	3	12,463	15	16,079	17	9,405		
	11	15,496			18	2,560		
	24	12,381						
	31	2,303						
Nov.	5	12						
1952								
June	14	260	22	1,327	21	1,716	23	819
	22	886						
July	8	6,111	11	4,237	9	5,767	10	8,634
Aug.	4	1,112	6	16,086	5	3,980	8	17,281
Sept.	1	5,204	3	7,031	4	3,008	5	432
Oct.	4	37,479	3	2,109	7	5,363	8	6,278
	26	2,932						
	31	14						

were reached in August or September, then decreased with the advent of the fall migration. The seasonal increases presumably resulted when the populations of smaller roosts joined the flights, as observed by Jones (1897), Monk (1933) and others. The daily variations noted in any one flight, other than those of a seasonal nature, were probably the results of several factors. The population of birds may have changed because some of the birds went to other roosts (Jones, 1897; Potter, 1912), or the estimations may have been at fault for one or more of several reasons already discussed.

Several of the variations in the totals of Table 44 were correlated with observed changes in bird behavior. The sharp drop in numbers after July 8, 1952, for the southwest flight, was caused when the birds began to use the catalpa grove near the west edge of Ames. The break-up of the north flight in 1951 was indicated by the drop in numbers about July 26. The erratic behavior of the east flight showed up as wide variations in totals obtained, as well as in the absence of any data at all for some of the evenings when observations were made.

Several rather large totals noted in Table 44 had no certainly known causes. The estimate for the east flight on September 30, 1950, and the large number for the south flight on October 4, 1952, were late enough in the year to have influx of migrants from farther north as a probable explanation. The relatively large total for the north flight on September 6, 1951, as well as the estimate for the south flight on August 6, 1952, undoubtedly came too early to be explained thus. Temporary union of several roosts may have been the cause.

Since the data obtained for the various flights (Table 44) were not uniformly distributed throughout the season, but were very grouped for some periods of time, simple averages did not seem justifiable to estimate the possible total roosting population in Ames. Neither did such averages seem entirely satisfactory as indices which would depict the relative sizes of the four flights. To get more reasonable estimates of the probable total roosting population, therefore, the highest estimates for the month from each flight were added, and the sums were then rounded. No sums were computed unless at least three flights were represented in the data for the month. The results are given in Table 45.

As the over-all averages in Table 45 indicate, the largest population of the roosting birds was present in 1950, and progressive decreases occurred in the following two years. Similar conclusions, discussed elsewhere in this thesis, were reached from periodic counts of the city blocks used by the birds. The monthly averages shown in the table failed to indicate such trends, probably because they were based on only three or four observations each.

Because of the difficulties connected with estimating the numbers in four separate populations of birds, the figures in Table 45 are probably underestimates. Had it been possible to get counts of all flights simultaneously, a number of times during the month, larger estimates would likely have resulted. Some of the indices shown were obtained from data gathered a number of days apart. It was certain that the writer, when he observed the birds in the roost area in the evening, had impressions of much larger populations than indicated in the table.

Table 45. Estimates of the probable total roosting population in Ames.

Month	Year		
	1950	1951	1952
June		1,300	4,700
July	25,200	17,700	24,800
August	37,600	41,500	38,500
September	69,300	65,700	15,700
October		41,000	51,300
Seasonal averages			
July-Sept.	44,000	41,600	26,300
June-Oct.		33,400	27,000

To get indices to represent the relative maximum sizes of the several flights, data gathered during the months of July to September were used. Other months were omitted because of lack of data for some flights. The index for each flight, for each year, was determined by adding the two highest estimates per month for July, August, and September, and then averaging and rounding the results. In several instances only one estimate was available for a month for a certain flight. The results are tabulated in Table 46.

Table 46. Relative maximum sizes of the flights as determined from the July to September estimates.

Year	Average numbers of birds per flight				Totals of flight averages
	Southwest	South	North	East	
1950	12,400	2,400	17,800	6,600	39,200
1951	17,500	5,700	7,600	5,100	35,900
1952	4,100	9,100	4,300	8,800	26,300

As can be seen from Table 46, the four flights were quite different in size, and in spite of its erratic behavior, only the east flight showed comparatively little change in average numbers during the three years. The large drop in numbers for the southwest flight resulted when about 20,000 birds began to use a catalpa grove near the west edge of the city, rather than go to the northeast Ames study area. Had they been included in the southwest flight, the index for 1952 would have been 10,800 instead of 4,100.

The indices in Table 46, for reasons similar to those given for Table 45, are undoubtedly too low to represent the populations that were actually present. Relatively they indicate that the several flights differed markedly from each other in numbers of birds present, that the same flight varied considerably in population from one year to the next, and that the flights changed their relative orders in regard to total numbers as the years passed. The progressive decrease in population during the three years, already discussed, is indicated in the "totals" column of the table.

Species composition

Numerous comments from residents in the roost area revealed that many of them believed starlings to be the predominant roosting species. Some even believed them to be the only birds present. That the roosting in Ames was not primarily a starling phenomenon, but one of bronzed grackles, was quite obvious to the investigator on almost any evening that population estimates were made of the flights. Data obtained in 1951, when the multiple counter was used repeatedly, were particularly good to show species composition. In 1950 and 1952 emphasis was placed on securing flock size data, and because many birds had to be recorded as unidentified, the data obtained were not of great value in determining relative abundance of species. Nothing was observed in those two years which was strikingly different from 1951. The 1951 data are summarized in Table 47.

As the means in Table 47 indicate, roughly three-fourths of the birds observed were bronzed grackles, and only the north flight showed

Table 47. Relative abundance of the several species of roosting birds in 1951.

Flight	Date	No. of birds	Per cent of the several species			
			Grackles	Starlings	Cowbirds	Robins
Southwest	June 21	258	91.1	5.8	0.4	2.7
	July 11	6,806	79.6	18.2	2.2	0.0
	31	10,964	78.7	16.7	4.0	0.6
	Aug. 17	10,500	75.7	13.3	9.5	1.5
	18	14,445	79.5	16.9	2.2	1.4
	19	14,027	76.0	20.5	2.5	1.0
	20	22,557	78.1	19.9	1.6	0.4
	21	20,205	79.6	14.0	6.0	0.5
	22	16,468	71.8	25.4	2.3	0.5
	23	20,800	82.4	16.3	0.8	0.5
	24	26,729	81.4	16.8	1.3	0.5
	Means	14,887	78.7	17.8	2.9	0.7
South	June 20	221	95.0	0.0	3.2	1.8
	July 12	1,318	61.6	29.0	7.6	1.8
	14	1,264	62.0	18.2	18.1	1.7
	17	994	74.0	21.1	1.4	3.4
	Aug. 1	2,481	50.3	43.1	6.1	0.5
	3	3,262	40.4	39.6	18.1	2.0
	27	432	7.4	76.9	7.6	8.1
	Sept. 18	20,279	86.1	9.5	3.7	0.7
	Means	3,781	74.7	18.0	6.2	1.1
East	Aug. 6	5,283	86.3	12.3	0.1	1.3
	7	9,696	78.7	18.0	1.0	2.4
	28	1,726	27.4	50.5	20.3	1.9
	Sept. 19	285	0.7	98.3	0.0	1.1
	Means	4,248	74.5	20.9	2.7	2.0

Table 47. (Continued)

Flight	Date		No. of birds	Per cent of the several species			
				Grackles	Starlings	Cowbirds	Robins
North	June	25	806	84.5	13.8	0.0	1.7
	July	18	3,511	68.0	30.5	1.0	0.5
		19	3,952	52.5	41.8	4.8	0.9
		20	4,265	50.9	39.4	9.0	0.8
		21	3,162	54.4	42.0	1.6	2.0
		22	3,370	50.1	44.9	3.7	1.3
		23	3,730	46.1	49.4	3.4	1.1
		24	4,121	45.3	47.9	4.9	1.9
		25	5,399	32.8	55.2	11.2	0.8
		26	3,710	44.7	44.2	10.1	1.0
		30	2,914	33.6	60.7	3.1	2.6
	Aug.	2	1,862	31.3	61.9	2.5	4.4
		13	1,718	13.3	81.7	3.4	1.6
	Sept.	6	30,325	84.7	14.4	0.8	0.1
		20	1,347	53.5	38.6	6.7	1.2
	Means		4,946	61.9	33.7	3.5	0.9
Means for all 4 flights combined			7,505	73.6	22.2	3.4	0.8

a considerable departure from this value with an index of 61.9 per cent. The starling mean percentages ranged in size from 17.8 for the southwest flight to 33.7 for the north flight. Cowbirds, except for a high mean of 6.2 per cent for the south flight, comprised about 3 per cent of the flight populations; and robins were present from less than 1 per cent to 2 per cent.

Relatively more grackles were present when flights first formed in June than later in the season, as Table 47 shows for the southwest, south, and north flights. When the starlings increased in numbers by the first part of July, the grackle percentages consequently decreased. Although there were variations, the percentages for the grackles and starlings of the southwest flight soon stabilized, but those for the other flights were more erratic.

The percentages obtained for the north flight (Table 47) gave further insight into the break-up noted near the end of July and the first of August in 1951. Since there was a decrease in percentage of grackles, while the total population was decreasing at the locality where the flight was watched, it was apparently primarily a portion of the grackle component of the flight that began to enter the roost area much farther west. Relatively few starlings shifted their point of entry westward, and consequently their percentage increased. Although the north flight had the highest percentage of starlings of any of the flights, the southwest flight had the greatest numbers.

Cowbird populations were very irregular from night to night, with the result that their percentages varied considerably (Table 47). On a

proportional basis the south and east flights were characterized by the highest percentages obtained for these birds, though greater numbers were present in the southwest flight.

Robin percentages might have been slightly higher had a special observer been present to count them. Because they came to the roost area in one's, two's, or very small flocks, they were frequently not noticed amidst thousands of grackles and starlings when the peaks of the flights were on. When special attention was given to them they could be identified among the other birds.

The flocks

Seasonal changes in size. A number of observers, including Jones (1897), Peck (1905), Monk (1933), and others, have noted that flights early in the season consisted of small groups of birds, or of single birds. As the season advanced, consolidation occurred and larger flocks were formed. Essentially the same situation occurred at Ames during the course of the investigation, as shown by data in Tables 48, 49, and 50.

Table 48, which summarizes the observations on grackle flocks, shows that early in the season practically all the birds came to roost in small groups. While the table does not indicate it directly, many birds arrived singly. Rapid changes then occurred, and by mid-July many birds arrived at the roost in larger flocks. Some of the flights even had over half the total population in flocks of 50 birds or larger by this time. By August, unless the grackle population in the flight was measured only in the hundreds, the percentages of birds that arrived in the largest flocks were usually in the 80's or even high 90's. As

Table 48. Change in size of bronzed grackle flocks with the advancing season.

Flight	Date			Total no. of grackles	Per cent of grackles in flocks of				
					1-5	6-10	11-20	21-50	Over 50
Southwest	1951	June	21	255	74.5	20.0	5.5	0.0	0.0
		July	10	4,517	7.4	8.1	9.3	22.9	52.4
		Aug.	17	7,945	0.2	0.0	0.0	0.0	99.8
			22	11,829	0.2	0.1	0.0	0.0	99.8
		Oct.	31	3,205	0.3	1.1	1.6	6.9	90.2
	1952	June	14	245	66.1	17.6	16.3	0.0	0.0
			22	1,501	13.1	6.5	10.0	25.1	45.3
		July	8	4,204	5.8	5.3	5.4	8.2	75.3
		Aug.	4	402	26.6	14.7	3.0	6.0	49.8
		Sept.	1	3,889	2.4	1.4	2.2	1.8	92.2
		Oct.	4	22,156	0.2	0.4	0.4	0.3	98.7
			26	2,380	0.5	0.0	0.6	3.8	95.2
South	1950	June	29	1,253	69.5	14.4	8.1	8.1	0.0
		July	11	1,086	25.0	13.8	15.8	26.5	17.3
			20	642	38.9	20.6	23.5	17.0	0.0
		Sept.	14	644	6.4	7.8	12.3	23.1	50.5
	1951	June	20	322	57.2	11.8	9.0	22.1	0.0
	1952	June	22	749	50.9	22.7	23.1	3.3	0.0
		July	11	1,421	12.0	7.1	7.7	15.4	57.7
		Aug.	6	13,887	0.9	0.3	0.8	1.4	96.6
		Sept.	3	1,196	5.3	4.5	5.3	8.4	76.5
		Oct.	3	895	4.0	1.0	15.1	3.4	76.5
North	1951	June	25	683	54.9	21.4	17.3	6.4	0.0
		July	21	1,720	8.1	4.3	5.4	1.5	80.8
			22	999	20.5	6.6	8.0	11.1	53.8
			23	1,564	7.5	1.5	2.2	0.0	88.8
	1952	June	21	1,673	35.2	17.0	12.6	31.6	3.6
		July	9	587	23.0	8.0	12.1	31.4	25.6
		Oct.	7	4,778	0.2	0.2	0.4	0.8	98.4
East	1952	June	23	716	41.1	21.8	24.3	12.9	0.0
		July	10	1,130	12.5	11.6	17.4	34.6	23.9

long as the grackle populations in the flights maintained large numbers, the high percentages in the large flocks continued. Smaller flights, regardless of the time of the year, had a lower per cent of birds in flocks of 50 birds or over.

In spite of the trend to form larger flocks with the advancing season, every flight during the entire summer and fall had some birds which came singly or in small groups. When the total grackle population for the day's flight was rather low, the per cent of such birds was correspondingly high.

In general, there was fairly close correspondence among the four flights in the time of development of the larger flocks, as Table 48 indicates, but there were some differences. On June 21, 1952, only 3.6 per cent of the birds of the north flight were in flocks over 50 birds in size, but on the next day, June 22, nearly half of the birds in the southwest flight were so organized. Since both flights had roughly the same total numbers of birds, factors intrinsic to the two populations must have been responsible.

Apparently the grackles at Ames behaved somewhat differently from those observed by Peck (1905) at Philadelphia, Pennsylvania. Peck found that the grackles came to the Overbrook roost as families in July, and that no flights existed until in August. At Ames the flights were well established by the end of June, if not earlier. Observations on June 6, 1952, revealed that no southwest flight was in existence. Eight days later, on June 14, a flight which involved 245 grackles was seen (Table 48). Of these, 16.3 per cent were already in flocks of 11 to 20 birds, much too large to be single families of grackles. Potter (1912) found

conditions in the Delaware valley similar to those observed in Ames, with flight lines quite definite by the last week in June.

Starlings developed large flocks in a manner similar to the grackles (Table 49), and whenever the two species individually numbered in the thousands in the flights, they showed comparable percentages of birds in the large flocks at equivalent times in the year. When each species was present only in the hundreds, but both were present in equal numbers in the flights, some differences were noted. Under those conditions starlings tended to have much larger percentages of their numbers appearing in larger flocks than was true for the grackles. For example, starlings on the south flight on August 4, 1952, numbered 386 and grackles numbered 402. While 90.7 per cent of the starlings were in flocks over 50, only 49.8 per cent of the grackles were in the larger flocks. On July 20, 1950, 82.5 per cent of the 679 starlings in the south flight were in flocks over 50, yet none of the 642 grackles in the same flight that day were in such large flocks. The same relationship existed when the species numbered somewhat better than 1,000 birds in the flights, as Table 49 shows. As an illustration, the south flight which existed on July 11, 1952, had 76.1 per cent of 1,249 starlings in groups over 50, but had only 57.7 per cent of 1,421 grackles in flocks of that size; and the east flight of July 10 of the same year had 23.9 per cent of 1,130 grackles in the largest flocks.

Cowbirds were ordinarily present in numbers which were too low (Table 50) to make possible any direct comparison with grackles such as has just been made for starlings. On most days they were not present

Table 49. Change in size of starling flocks with the advancing season.

Flight	Date		Total no. of starlings	Per cent of starlings in flocks of				
				1-5	6-10	11-20	21-50	Over 50
Southwest	1951	June 21	20	100.0	0.0	0.0	0.0	0.0
		July 10	508	9.6	10.4	17.9	10.8	51.2
		Aug. 17	1,395	0.9	0.9	0.0	5.7	92.5
		Oct. 31	506	4.7	5.3	5.9	22.7	61.3
	1952	June 14	5	100.0	0.0	0.0	0.0	0.0
		Aug. 4	386	3.6	5.7	0.0	0.0	90.7
		Sept. 1	880	1.9	2.3	4.9	0.0	90.9
		Oct. 4	14,868	0.1	0.1	0.4	1.2	98.2
South	1950	June 29	177	74.6	25.4	0.0	0.0	0.0
		July 11	137	12.4	6.6	29.9	51.1	0.0
		20	679	5.2	2.4	6.3	3.7	82.5
		Sept. 8	875	1.0	1.1	4.1	0.0	93.7
	1951	June 20	7	100.0	0.0	0.0	0.0	0.0
	1952	June 22	511	4.7	7.6	9.4	32.3	46.0
		July 11	1,249	1.7	2.1	2.8	17.4	76.1
		Sept. 3	3,246	0.7	0.0	0.5	6.6	92.3
		Oct. 3	204	2.0	0.0	0.0	0.0	98.0
North	1951	June 25	112	33.0	8.9	0.0	58.0	0.0
		July 22	579	9.5	2.1	9.8	19.9	58.7
	1952	June 21	22	36.4	63.6	0.0	0.0	0.0
		Oct. 7	335	13.7	2.4	18.2	17.9	47.8
East	1952	June 23	80	77.5	7.5	15.0	0.0	0.0
		July 10	769	7.5	11.3	14.8	58.5	7.8
		Sept. 5	376	5.9	2.4	0.0	12.0	79.8
		Oct. 8	245	2.0	0.0	0.0	32.7	65.3

Table 50. Change in size of cowbird flocks with the advancing season.

Flight	Date		Total no. of cowbirds	Per cent of cowbirds in flocks of				
				1-5	6-10	11-20	21-50	Over 50
Southwest	1951	July 10	71	21.1	43.7	35.2	0.0	0.0
	1952	Aug. 4	230	4.8	9.1	12.2	47.8	26.1
		Oct. 4	202	6.0	0.0	9.9	84.2	0.0
South	1950	June 29	52	50.0	11.5	38.5	0.0	0.0
		July 11	20	10.0	30.0	60.0	0.0	0.0
		20	146	11.0	0.0	0.0	20.6	68.5
		Sept. 8	169	0.0	0.0	17.2	50.3	32.5
	1951	June 20	7	0.0	100.0	0.0	0.0	0.0
	1952	June 22	22	40.9	59.1	0.0	0.0	0.0
		July 11	40	47.5	17.5	35.0	0.0	0.0
		Aug. 6	690	2.5	5.5	9.4	39.9	42.8
		Sept. 3	1,663	0.3	0.8	2.1	8.4	88.4
		Oct. 3	185	2.7	5.4	10.8	0.0	81.1
North	1951	July 21	31	25.8	74.2	0.0	0.0	0.0
		22	89	7.9	0.0	67.4	24.7	0.0
		23	76	4.0	38.2	18.4	39.5	0.0
	1952	June 21	18	16.7	0.0	83.3	0.0	0.0
		July 9	45	17.8	17.8	64.4	0.0	0.0
		Aug. 5	67	4.5	14.9	43.3	37.3	0.0
East	1952	June 23	32	6.3	0.0	0.0	93.8	0.0
		Oct. 8	130	0.0	0.0	0.0	23.1	76.9

in large enough numbers to form flocks over 50 birds in size. A tendency to form the larger flocks was indicated by the decreasing per cent of birds in flocks of one to five birds, and of six to 10, as the season advanced. Although flocks of cowbirds ordinarily were small, most of them less than 25 birds in size, Table 50 indicates some decidedly definite exceptions.

Data for robins, comparable to that given for the other roosting birds in Tables 48 to 50, are not included. As is explained elsewhere in this thesis, almost no data were collected for robins whenever the peaks of the grackle and starling flights were on. Robins commonly came in one's, two's, or other small groups, and occasionally flocks of 30 or more were seen. In comparison to flocks of grackles, starlings, or cowbirds, they were loosely organized, and individual birds were quite apt to stop in some tree while the remainder of the flock flew on. Frequently observed to follow the flight lines of the other species of birds, they never seemed closely bound to the flocks.

Mixed flocks. Many of the birds arrived at the roost area in mixed flocks, rather than in single-species groups. It was not very difficult, with the aid of the multiple counter, to get total number estimates of the several species of birds every 10 minutes, though isolated birds, as was true for robins, were easily overlooked when the flights reached their peaks. To get written records of individual mixed flocks was another story, for the birds came entirely too rapidly for one observer to count and also to record the results. To get such data, several people, unavailable for this research, were needed.

With the exception of the robins, which were always too few in number ever to be in the majority, observations indicated that grackles, starlings, and cowbirds mixed in various proportions. Because grackles were the most numerous of the species, they were usually in the majority in mixed flocks; but many groups were seen where only a very small number of them, even two or three, were present in a flock of starlings or cowbirds, or of a mixture of the two. Long strings of birds in August and September were frequently seen to contain all four species of birds. On occasion a mourning dove, Zenaidura macroura carolinensis (Linnaeus), was seen flying with the birds for at least 500 feet or so before it broke away from the flight. Although both English sparrows and purple martins roosted with the other species on occasion, they were never observed to fly with them.

Shape and appearance. By and large, the shapes of the grackle flocks seen at Ames fitted the description given by Jones (1897). Flocks of only a few birds had every conceivable shape, but when they involved considerable numbers they invariably were drawn out parallel to the line of flight. Some flocks were roughly spindle-shaped, and others had alternate bulges and narrow places.

In addition to the lengths of the flocks, which increased as the total population increased, only one major seasonal change in the appearance of the flocks was noted at Ames. During October, when populations at the roost were on the decrease, many of the grackle flocks tended to be oval or spherical and seemed much more compact than at other times in the year. The birds in such flocks invariably had a more rapid

flight than those flying in drawn-out streams, and a second look was frequently given these groups by the writer to be sure of identification.

Starling flocks were commonly spindle-shaped, oval, or globular until they approached the roost area at Ames. When they neared their destination such flocks almost always fanned out at right angles to their line of flight, and the birds then frequently held their wings rigid and glided for some distance. This maneuver as often aided as hindered getting estimates of the numbers of birds present. Many starling flocks were already drawn out at right angles to their line of flight when they reached the point of observation, though the birds then were not gliding. Starling flocks were invariably more compact in appearance than those of the grackles.

Cowbird flocks were usually rather compact, oval or globular in shape, and, if more than 25 or 30 birds were present, were commonly drawn out at right angles to their line of flight. Although the flocks were not much different in general appearance from starling flocks of the same size, little difficulty in identification resulted. The bobbing flight of the cowbirds was quite different from the straight, rapid flight of the starlings, even when seen at a distance against the sky.

The shapes of the flocks seen at Ames, regardless of bird species, were rather fluid and changing. No flock was ever seen to maintain a rigid formation, and birds in the lead one moment were quite apt to be farther back in the flock at another. No evidence was ever seen of a leader in the flock, as was reported by Nuttall (1832).

Altitude of flight

The several species of roosting birds came to the roost area at characteristic altitudes. As observed at the points of observation, grackles of all four flights usually flew slightly above the tree tops, which ordinarily meant about 60 to 90 feet above the ground. Cowbird flocks tended to be an estimated 10 to 20 feet higher, though many flew at the same height as the grackles; and flocks composed only of starlings came at altitudes two or more times that of the grackles. Robins, though not infrequently between grackle and starling levels, ordinarily came just above the tree tops or even lower among the trees.

Mixtures of species were commonly seen slightly above tree-top height, the altitude normally used by the most abundant birds, the bronzed grackles. When mixed flocks contained preponderant numbers of cowbirds, they flew at levels characteristic of the cowbirds. No mixed groups were ever noted at the higher altitudes so typical of starlings when by themselves.

On perhaps nine or 10 evenings during the course of the study, the birds were noted to be at somewhat higher altitudes than usual. Because the phenomenon was observed on overcast days and on clear, when there was little wind or moderate wind, when the wind came from six different directions, when there was a rising barometer or a falling one, as early as August 6 and as late as October 26, no particular environmental factor was ever detected as the responsible stimulus. Temperature and humidity readings were obtained on only four of the days when the birds flew higher, and therefore present rather limited data. Nevertheless, since

at the beginnings of the flights the temperatures were as low as 61 and as high as 81 degrees Fahrenheit, and since relative humidities ranged from 63.5 to 74.5 per cent, these weather phenomena also were probably not the causative factors.

Strong gusty winds several times apparently were responsible for lower-than-usual flight. Under such circumstances many of the birds sought the shelter of trees wherever possible. Starlings were never noted as flying high on very windy days.

Timing of the flights

Beginnings, peaks, endings. Table 51 summarizes, in terms of minutes to sunset, the daily times of arrival of the bronzed grackles, starlings, and cowbirds of the southwest and north flights. Similar data for the east and south flights, though considerably more limited, are given in Table 52. For each of the three species of birds data for the beginnings, peaks, and endings of the flights are given in both tables. Positive numbers in the third, fourth, and fifth columns represent time before sunset, and negative numbers indicate time after sunset. The last two columns in the table compare the times of arrival of the starlings and cowbirds with those of the grackles. In these two columns the positive numbers indicate time in advance of that for grackles, and negative numbers show time later than for grackles.

For purposes of this investigation the time was divided into 10-minute intervals which began on the hour. As is discussed in the section, "Method of Procedure", weather data and bird counts were recorded at the beginnings of each of these intervals. Central standard time was used

Table 51. A comparison of the times of flight beginnings, peaks, and endings of the southwest and north flights in 1951.

Flight	Date	Minutes to sunset: Grackles B*	Grackles P**	Grackles E***	Starlings B	Starlings P	Starlings E	Cowbirds B	Cowbirds P	Cowbirds E	Starling time minus grackle time: B	P	E	Cowbird time minus grackle time: B	P	E
South-west	6/21	54	34	-26	44	34	4	—	—	—	-10	0	30	—	—	—
	7/11	93	43	-17	73	43	- 7	73	53	23	-20	0	10	-20	10	40
	31	68	- 2	-22	38	18	- 2	48	28	- 2	-30	20	20	-20	30	20
	8/17	37	2	-13	47	17	- 3	37	17	- 3	10	15	10	0	15	10
	18	45	- 5	-15	35	15	-15	45	15	5	-10	20	0	0	20	20
	19	54	4	- 6	54	24	4	44	24	24	0	20	10	-10	20	30
	20	62	12	- 8	52	22	- 8	42	32	12	-10	10	0	-20	20	20
	21	41	- 4	-19	41	11	- 4	41	11	- 4	0	15	15	0	15	15
	22	49	4	-11	39	4	-11	39	19	9	-10	0	0	-10	15	20
	23	48	13	-12	48	13	-12	48	38	18	0	0	0	0	25	30
	24	76	6	-14	76	16	-14	76	76	26	0	10	0	0	70	40
	10/ 1	53	3	- 7	43	13	3	33	13	3	-10	10	10	-20	10	10
	3	30	5	-15	30	5	-10	30	30	-10	0	0	5	0	25	5
	24	58	3	-22	18	3	- 7	3	3	3	-40	0	15	-55	0	25
	Means	54.9	8.4	-14.8	45.6	17.0	- 5.9	43.0	27.6	8.0	- 9.3	8.6	8.9	-11.9	21.2	21.9
North	6/25	75	45	-15	65	25	5	—	—	—	-10	-20	20	—	—	—
	7/18	69	19	-21	64	39	9	49	49	19	- 5	20	30	-20	30	40
	19	88	28	-12	48	28	8	83	58	28	-40	0	20	- 5	30	40
	20	87	17	-13	67	7	-13	57	37	17	-20	-10	0	-30	20	30
	21	77	27	-13	77	7	- 3	47	- 3	- 3	0	-20	10	-30	-30	10

* Beginning of the flight
** Peak of the flight
*** Ending of the flight

Table 51. (Continued)

Flight	Date	Minutes to sunset: Grackles			Starlings			Cowbirds			Starling time minus grackle time			Cowbird time minus grackle time		
		B	P	E	B	P	E	B	P	E	B	P	E	B	P	E
North	7/22	66	26	-14	56	16	6	66	41	16	-10	-10	20	0	15	30
cont'd	23	75	15	-25	45	15	-15	45	45	15	-30	0	40	-30	30	40
	24	94	14	-16	54	14	- 6	64	34	- 6	-40	0	10	-30	20	10
	25	83	13	-17	53	13	- 7	73	43	3	-30	0	10	-10	30	20
	26	63	13	- 7	63	23	3	63	33	23	0	10	10	0	20	30
	30	59	19	-11	49	19	-11	49	39	4	-10	0	0	-10	20	15
	8/ 2	55	15	-15	45	15	- 5	45	20	- 5	-10	0	10	-10	5	10
	13	62	22	- 8	42	22	- 8	42	32	12	-20	0	0	-20	10	20
	9/ 6	35	5	- 5	35	15	- 5	35	25	15	0	10	0	0	20	20
	7	43	33	3	43	23	13	43	23	13	0	-10	10	0	-10	10
	24	55	25	5	55	35	25	65	45	45	0	10	20	0	20	40
	Means	67.9	21.0	-11.5	53.8	19.8	- 0.3	55.1	34.7	13.1	-14.1	- 1.3	13.1	-12.3	15.3	24.3
Means for southwest and north flights combined		61.8	15.1	-13.0	50.0	18.5	- 2.6	49.5	31.4	10.7	-11.8	3.3	11.2	-12.1	18.0	23.2

Table 52. A comparison of the times of flight beginnings, peaks, and endings of the south and east flights in 1951 and 1952, and of the southwest and north flights in 1952.

Flight	Date	Minutes to sunset									Starling time minus grackle time			Cowbird time minus grackle time		
		Grackles			Starlings			Cowbirds								
		B	P	E	B	P	E	B	P	E	B	P	E	B	P	E
South	1951															
	7/12	92	32	- 8	72	32	2	52	12	2	-20	0	10	-40	-20	10
	14	71	11	-29	61	21	11	71	11	11	-10	10	40	0	0	40
	17	90	40	0	60	40	40	50	40	40	-30	0	40	-40	0	40
	8/ 1	66	16	- 4	46	26	6	46	36	16	-20	10	10	-20	20	20
	3	54	4	-26	34	14	- 6	54	34	-16	-20	10	20	0	30	10
	9/18	45	5	- 5	35	5	- 5	35	15	15	-10	0	0	-10	10	20
	Means	69.7	18.0	-12.0	51.3	23.0	8.0	51.3	24.7	11.3	-18.3	5.0	20.0	-18.3	6.7	23.3
	1952															
	6/22	95	25	-25	65	5	- 5	25	5	- 5	-30	-20	20	-40	-20	20
	7/11	63	33	- 7	53	43	- 7	43	33	18	-10	10	0	-20	0	25
	8/ 6	51	21	- 9	71	31	11	71	41	1	20	10	20	20	20	10
	9/ 3	40	10	-10	40	20	0	30	0	0	0	10	10	-10	-10	10
	10/ 3	50	10	-10	20	10	10	40	30	20	-30	0	20	-10	20	30
	Means	59.8	19.8	-12.2	49.8	21.8	1.8	41.8	21.8	6.8	-10.0	2.0	14.0	-20.0	2.0	19.0
East	1951															
	8/ 6	41	31	- 9	31	21	11	—	—	—	-10	-10	20	—	—	—
	7	60	20	0	50	20	20	40	30	20	-10	0	20	-20	10	20
	28	50	40	30	30	30	10	30	20	20	-20	-10	-20	-20	-20	-10
	Means	50.3	30.3	7.0	37.0	23.7	13.7	35.0	25.0	20.0	-13.3	- 6.7	6.7	-20.0	- 5.0	5.0

Table 52. (Continued)

Flight	Date	Minutes to sunset									Starling time minus grackle time			Cowbird time minus grackle time		
		Grackles			Starlings			Cowbirds								
		B	P	E	B	P	E	B	P	E	B	P	E	B	P	E
East	1952															
	6/23	95	35	- 5	85	55	15	45	45	45	-10	20	20	-50	10	50
	7/10	63	33	- 7	63	33	- 7	—	—	—	0	0	0	—	—	—
	8/ 8	78	68	8	78	48	18	68	48	18	0	-20	10	-10	-20	10
	10/8	22	12	2	22	22	22	2	2	2	0	10	20	-20	-10	0
	Means	64.5	37.0	- 0.5	62.0	39.5	12.0	38.3	31.7	21.7	- 2.5	2.5	12.5	-26.6	- 6.7	20.0
South-west	1952															
	7/ 8	93	3	-27	43	8	3	83	23	- 7	-50	5	0	-10	20	20
	8/ 4	63	3	-17	43	43	3	63	53	3	-20	40	0	0	50	20
	9/ 1	54	4	-16	54	19	14	—	—	—	0	15	10	—	—	—
	10/ 4	78	18	- 2	68	18	8	58	58	28	-10	0	-10	-20	40	30
	26	65	5	5	15	5	0	—	—	—	-50	0	- 5	—	—	—
	Means	70.6	6.6	-11.4	44.6	18.6	5.6	68.0	44.7	8.0	-26.0	12.0	- 1.0	-10.0	36.7	23.3
North	1952															
	6/21	94	24	-26	84	4	4	74	24	24	-10	-20	30	-20	0	50
	7/ 9	63	13	- 7	53	23	13	—	—	—	-10	10	20	—	—	—
	8/ 5	82	32	2	72	42	22	72	72	22	-10	10	20	-10	40	20
	10/ 7	33	23	3	33	23	13	3	3	3	0	0	10	-30	-20	0
	Means	68.0	23.0	- 7.0	60.5	23.0	13.0	49.7	33.0	16.3	- 7.5	0.0	20.0	-20.0	6.7	35.0

throughout the study, and sunset times used were those listed by Hansen (1951).

The time of beginning of a flight, for a given species of bird, was taken to be the middle of that 10-minute period during which at least one bird arrived and which was immediately followed by another 10-minute period during which at least one bird arrived. This definition was adopted to avoid extreme decisions as to the time when a flight began, for it happened on a number of evenings that one or two grackles flew toward the roost area fully 15 to 30 minutes before any others arrived. Quite satisfactory for grackles and starlings, the definition did not always work for the less abundant cowbirds. When a flock of more than five cowbirds arrived, even if it was 15 to 20 minutes ahead of any others, the birds were listed in the appropriate 10-minute interval and considered as beginning the flight. When no more than five arrived, they were not listed as beginning the flight unless the succeeding 10-minute interval disclosed at least one bird going toward the roost.

The time for the peak of a flight, for any one species of bird, was taken as the middle of the 10-minute interval during which the greatest number of that species arrived, and the time of ending was the mid-point of the 10-minute interval during which the last two or more birds arrived. When only one bird arrived during the last 10-minute period, the preceding interval was taken as ending the flight. These designations worked satisfactorily for the cowbirds, as well as for the grackles and starlings.

Because robins were invariable lost to observation when the peaks of the flights for the other birds were on, they are not considered in

this section.

Observations indicated that in 1951 the southwest and north flights tended to come to the roost at comparable times. For graphic purposes, therefore, the pertinent data from Table 51 were combined to produce Figures 18 to 20. Similar combinations were not made for other flights because of limited data, or because the flights seemed to have somewhat different times of arrival.

Times of flight beginnings showed a tendency to occur closer to sunset time as the season advanced. The tendency for the grackles (Figure 18) was quite definite, though limited data in June and late October left some doubt concerning the trends then. Starlings showed similar changes during the season (Figure 19), except that the wide deviations away from sunset time in October, such as were observed for the grackles, were not noted. Cowbirds showed comparable behavior (Figure 20), but apparently were not present in any numbers at the roost during June and in October. Over-all means for the year disclosed an average time of arrival before sunset of 61.8 minutes for the grackles, 50.0 minutes for starlings, and 49.5 minutes for cowbirds. Thus, the grackles came first, and the starlings and cowbirds began to arrive at about the same time a little later.

The means of the preceding paragraph, as well as those mentioned later for flight peaks and endings, must be interpreted cautiously. The data are considerably grouped for July and August, as Figures 18 to 20 indicate. Values for successive days tend to be similar, whereas those for days with long intervals between tend to be different. Consequently

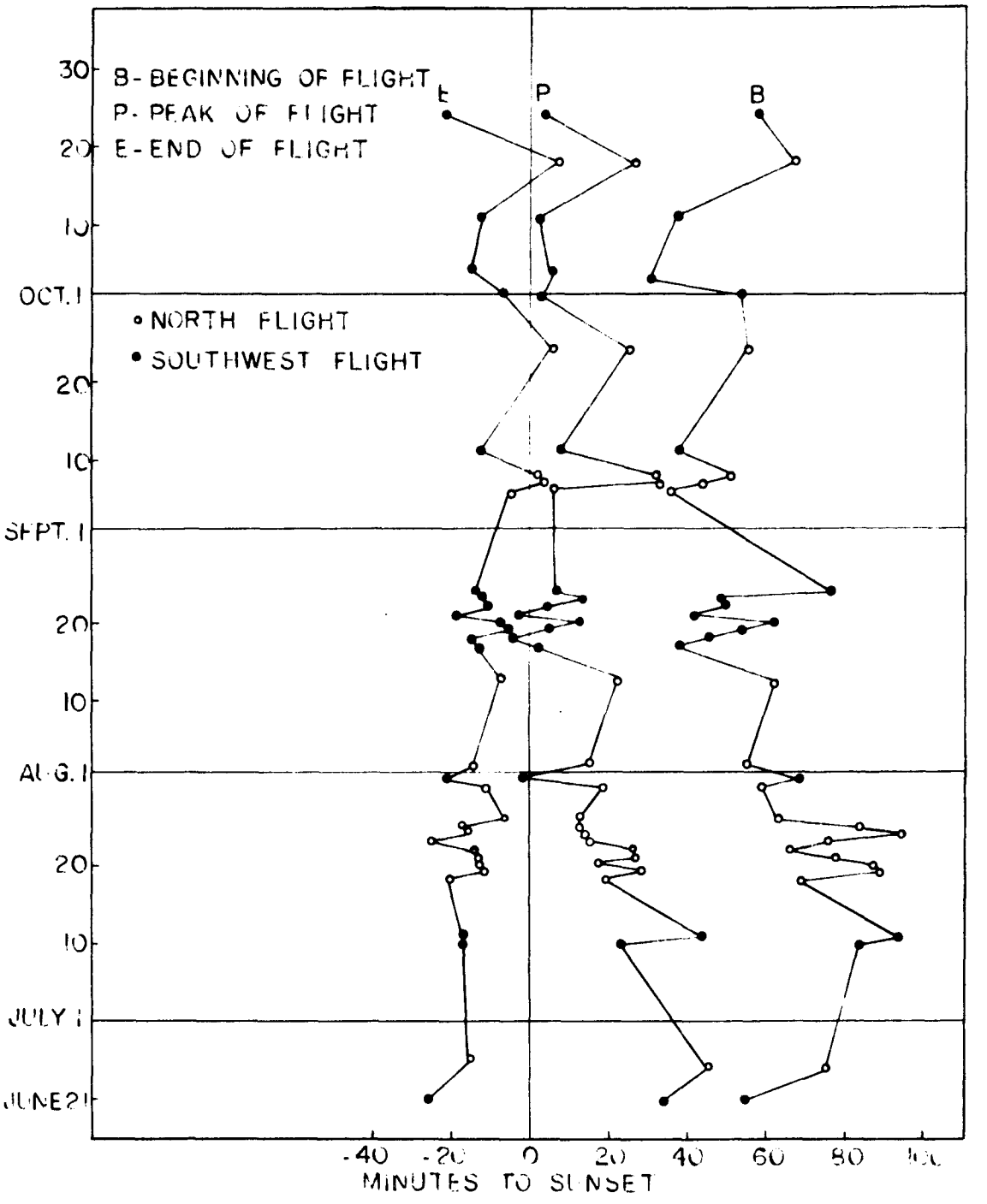


Figure 18. Times of flight beginning, peak, and ending for grackles of the southwest and north flights in 1951.

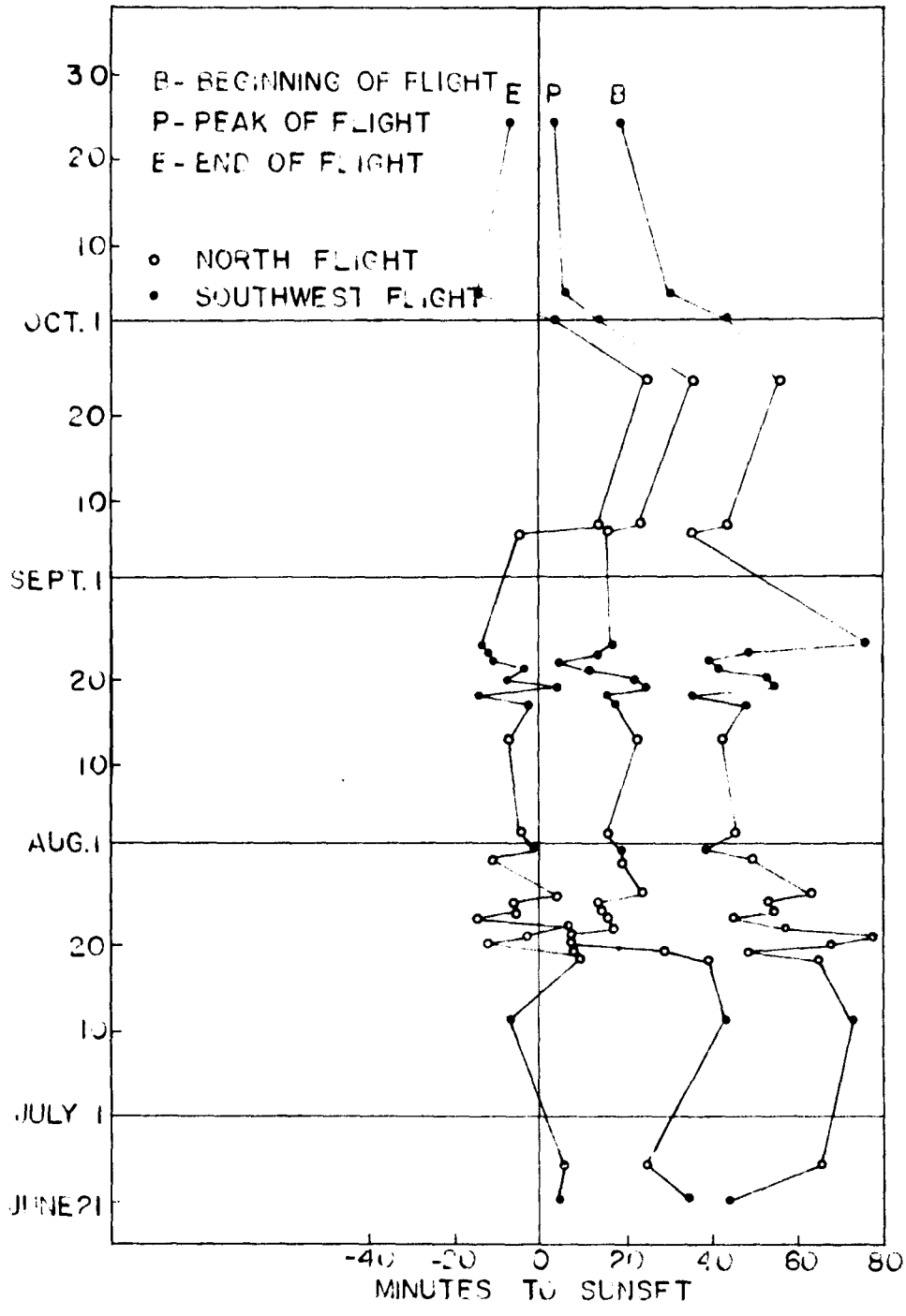


Figure 19. Times of flight beginning, peak, and ending for starlings of the southwest and north flights in 1951.

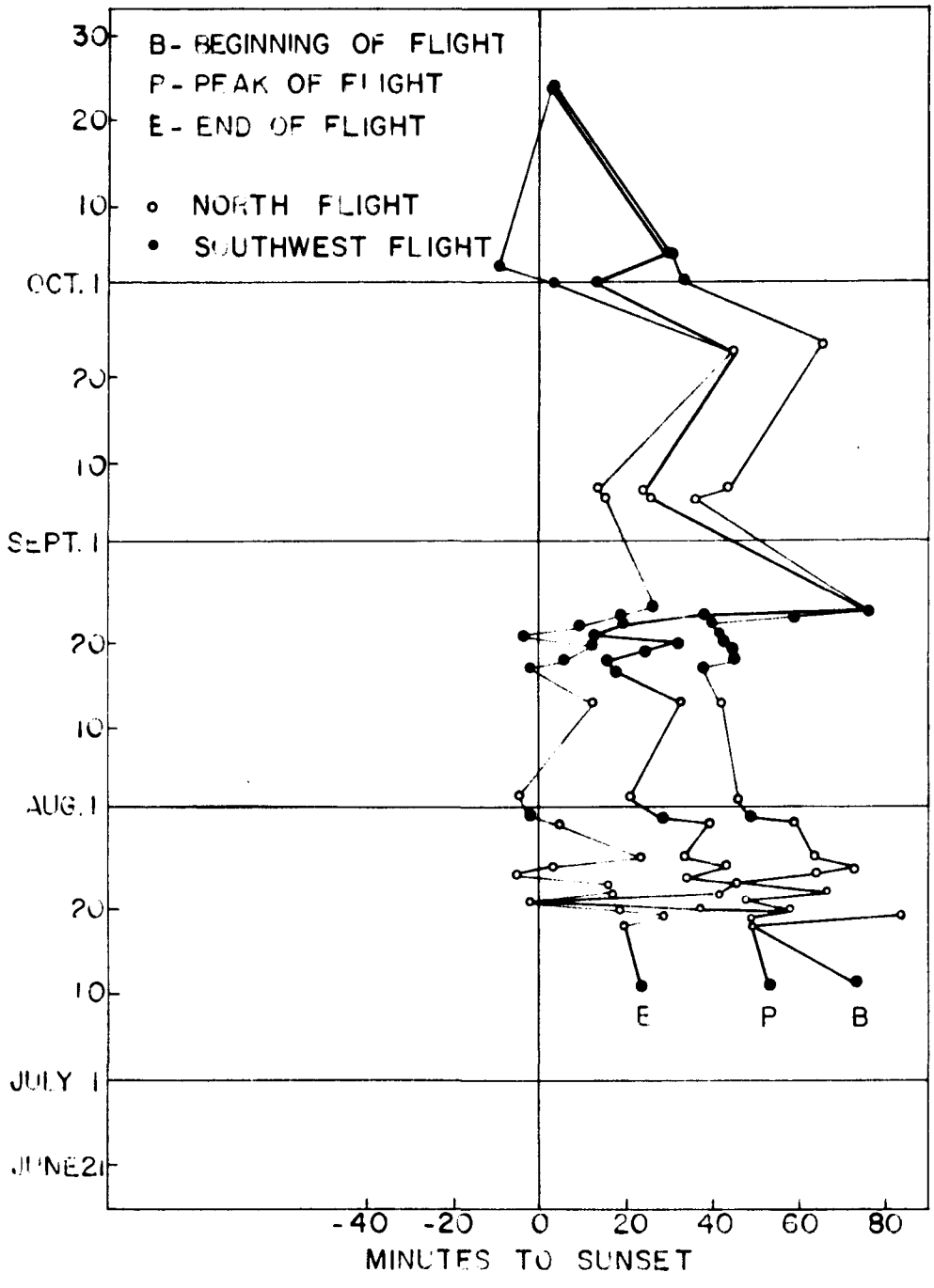


Figure 20. Times of flight beginning, peak, and ending for cowbirds of the southwest and north flights in 1951.

the grouped data have undue weight in determining the means. On a relative basis, since data for all the birds are available for nearly all days, this causes no difficulty, and the means make it possible to compare the behavior of the three species of the two flights in 1951.

Since the times for the peaks of the flights tended to parallel the times of flight beginnings (Figures 18 to 20), they tended to occur nearer to sunset as the season advanced. With the exception of three evenings, during which the peaks for the grackles occurred after sunset, all peaks for the three species of birds took place before sunset. Over-all averages for the peaks, in minutes before sunset, were as follows: grackles, 15.1; starlings, 18.5; cowbirds, 31.4. Thus, the cowbird peaks came first, starlings second, and grackles last.

Cowbirds, with a few exceptions, had completed their flights by sunset (Figure 20), but grackles and starlings ordinarily finished their daily trip to the roost after sunset (Figures 18 and 19, respectively). For grackles (Figure 18) there was a seasonal tendency for the time of flight ending to occur nearer sunset, but data in October were too few to establish trends definitely at that time. No special changing trend for starling flight endings was obvious during the investigation, and Figure 19 shows that the birds were ordinarily at the roost very shortly after sunset. The 1951 averages disclosed that grackle flights ended at 13 minutes after sunset, starlings finished two and six-tenths minutes after sunset, and cowbirds were all at the roost by 10.7 minutes before sunset. In other words, cowbirds finished their flights first, on the average, and were followed by starlings and then grackles.

As the season progressed the total duration of the flights of the several species decreased. The grackles (Figure 18) accomplished this both by beginning to come to the roost closer to sunset and also by finishing sooner after sunset. Starlings (Figure 19) had little seasonal change in time of flight ending, but shortened their total flight period by coming to the roost nearer to sunset time later in the year. Cowbirds behaved like the starlings in this respect, as is shown by Figure 20.

In Figures 21 and 22 are graphed the data of the sixth and seventh columns, respectively, of Table 51. In these figures the flight times of the starlings and cowbirds are compared directly with the equivalent data for the grackles.

Figure 21 emphasizes that the starlings tended to begin their flights later than the grackles. The average for the year was 11.8 minutes later. A seasonal change occurred, and by late August both species of birds tended to arrive at the roost area during the same 10-minute intervals. As far as the peaks of flights were concerned, Figure 21 depicts little difference between the times of the grackles and of the starlings, and the year's mean, as additional evidence, indicated that the starling peaks occurred only three and three-tenths minutes before grackle peaks. No particular change was noted with the season. Flight endings presented a different picture, for the graph shows that the starlings either ended their flight before the grackles, or ended it with them. The annual mean was 11.2 minutes before grackle time. With the advancing season, at least until early in September, the differences in ending time for the two species became less and less. Thereafter a tendency to increase the differences seemed to exist (Figure 21), though the observations were

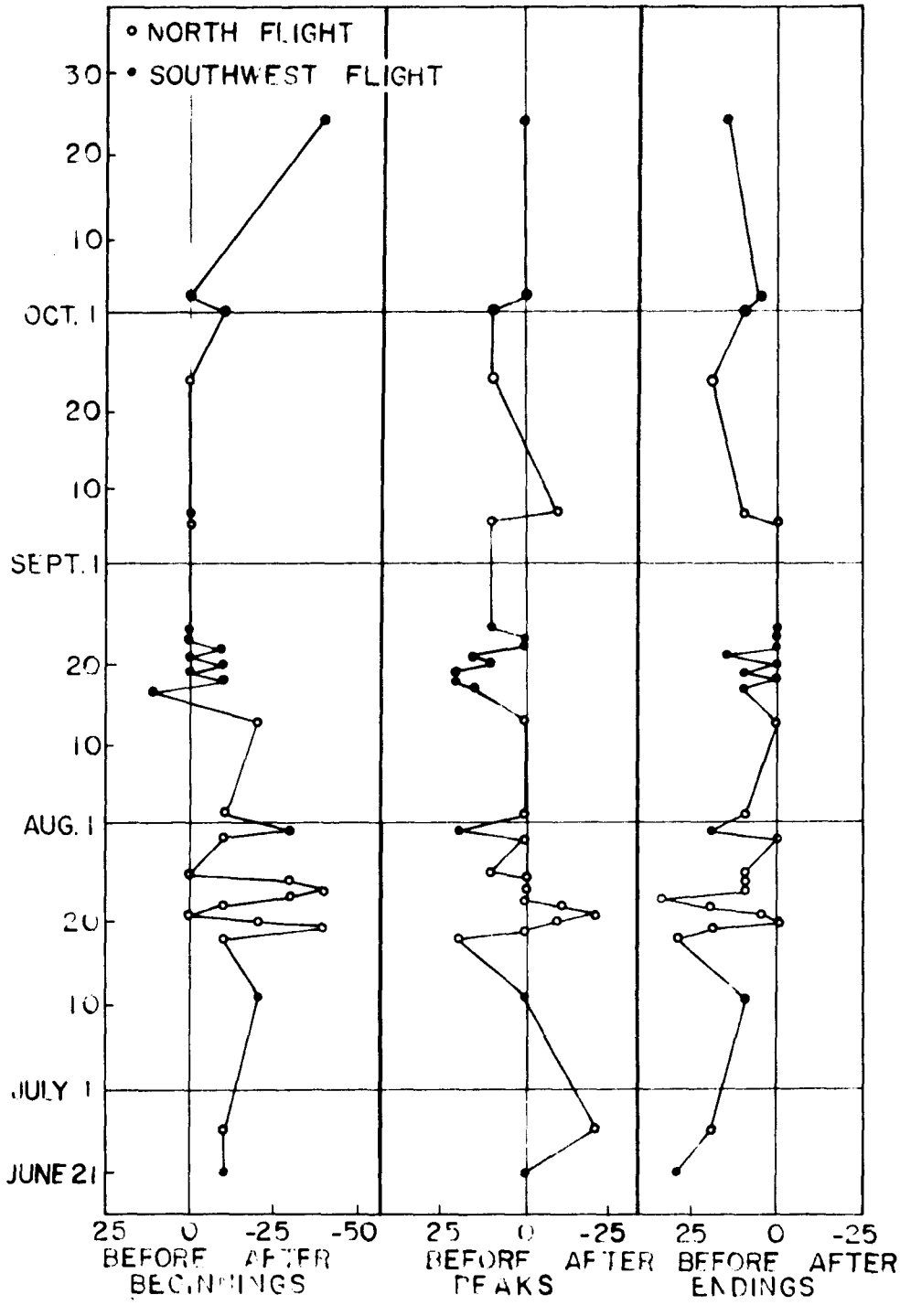


Figure 21. Times of flight beginning, peak, and ending for starlings of the southwest and north flights, with reference to those of the grackles.

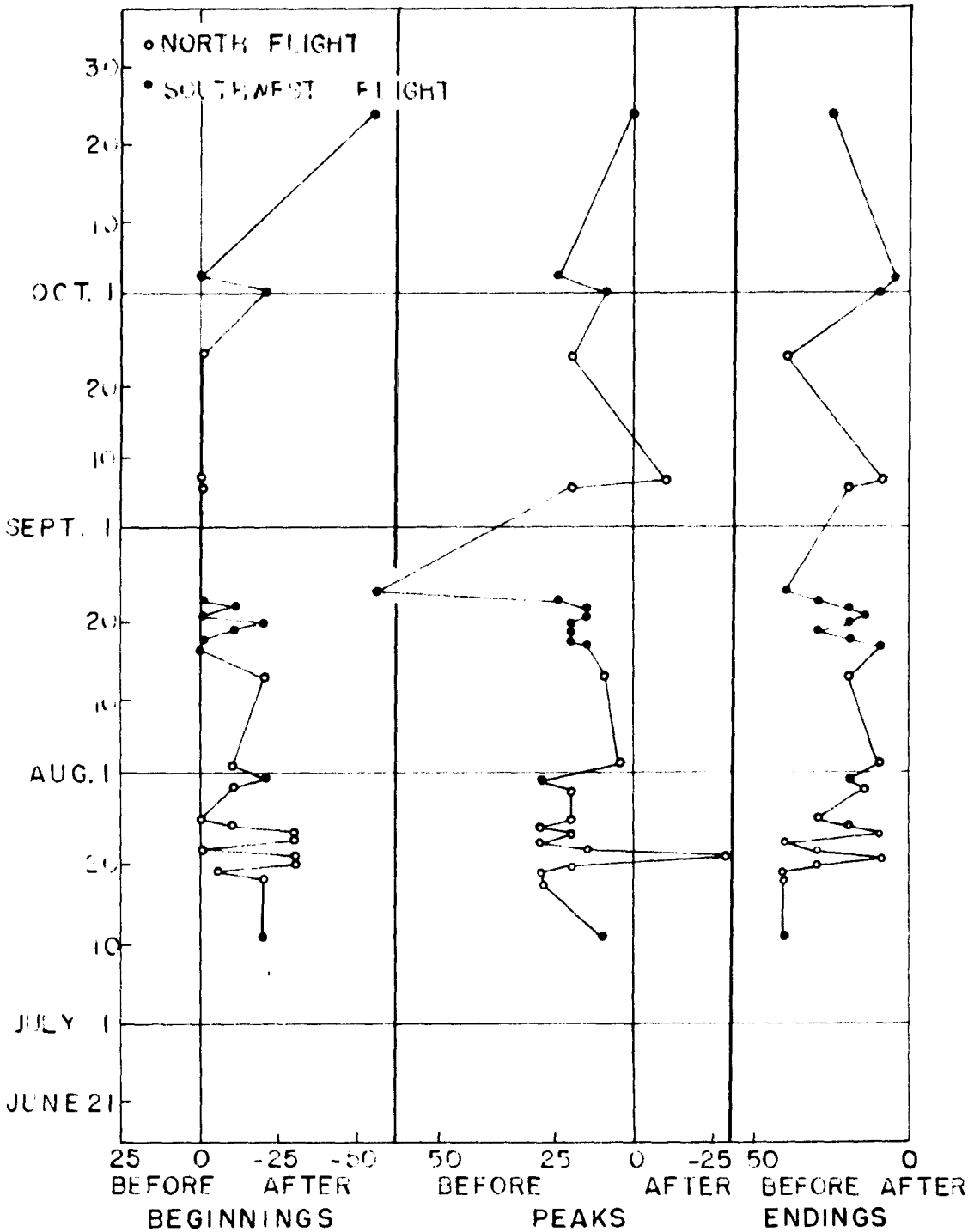


Figure 22. Times of flight beginning, peak, and ending for cowbirds of the southwest and north flights, with reference to those of the grackles.

rather few to draw definite conclusions.

As far as flight beginning time was concerned, cowbirds behaved in a manner similar to the starlings. The 1951 mean was 12.1 minutes after the grackles, almost the same as that of the starlings, and consequently the graph in Figure 22 is highly similar to that in Figure 21. Cowbird flight peaks occurred at relatively extreme times, yet they averaged 18 minutes earlier than the grackles. There seemed to be a trend for the cowbird peak times to approach that of the grackles, but it was a very slight one. The cowbirds ended their flights 23.2 minutes before the grackles on the average, and tended to show a seasonal trend similar to that followed by the starlings (Figure 22).

Thus, the birds began to arrive at the roost in the following order: grackles, starlings and cowbirds, with almost no difference between the last two species. For flight peaks the order was completely reversed: cowbirds, starlings, grackles, with only about three minutes difference between the last two species. For flight endings, the same order as observed for peaks was noted: cowbirds, starlings, grackles, with about 10 or more minutes interval between each.

Although the information is not recorded in Tables 51 or 52, it was noted that robins were the last birds to arrive at the roost. On many evenings they came in constant numbers when only stragglers among the grackles or starlings were to be seen. Some few individuals almost always arrived as early as the first grackles or starlings, but from then on the arrivals were thinly strung out until much later in the evening.

At Columbus, Ohio, Nice (1935) noted the time of arrival of grackles and starlings on five evenings between October 6 and 15, 1934. She

found that the first flocks of both species arrived one-half hour before sunset. The largest flocks arrived from nine to 14 minutes before sunset on clear evenings and from five to 16 minutes before sunset when it was cloudy. The flight ended from one minute before to three minutes after sunset.

Comparable data for the Ames flights are rather limited, but two observations for the southwest flight on October 1 and 3, 1951 (Table 51), suggested that the Ames grackles and starlings began their flight earlier. Grackle peaks at Ames came closer to sunset than observed by Nice (1935), but starling peaks came within the range of time she noted. Grackles ended their flights considerably later at Ames, and starlings at Ames showed a greater range of time for the endings.

One observation from each of the four flights at Ames in early October, 1952 (Table 52), disclosed that grackles arrived from 22 to 78 minutes before sunset, with an average of 45.8 minutes. Grackle peaks ranged from 10 to 23 minutes before sunset, and averaged 15.7. The endings of the flights came between three minutes before to 10 minutes after sunset. Thus, as compared with the grackles at Columbus (Nice, 1935), the Ames grackles in 1952 began their flights a little earlier, and had a greater range for peaks and endings.

Similar observations for starlings in October, 1952, showed that they arrived from 20 to 68 minutes before sunset, with an average of 35.8 minutes. Their peaks came between 10 and 23 minutes before sunset, and averaged 18.3 minutes. They ended their flights from eight to 22 minutes before sunset, with an average of 13.3 minutes. Thus the starlings at Ames averaged about the same in flight beginning as the birds

observed by Nice (1935), the peaks came a few minutes earlier on the average, and the terminations of the flights came considerably earlier.

Comparable data for Columbus, Ohio (Nice, 1935), and Ames are actually too limited to draw any definite conclusions, but the few data that do exist tend to indicate greater variability at Ames, and a tendency for the birds at Ames to have had a longer flight duration.

Factors influencing variations. Although there were seasonal trends for the times of flight beginnings, peaks, and endings, as Tables 51 and 52 and Figures 18 to 20 indicate, there were also wide variations on a daily basis. Since it became obvious, soon after the investigation was under way, that the birds came to roost earlier on dark days than on clear days, weather elements were thought to be the cause. During 1951 and 1952, therefore, data on the more readily measurable weather factors were collected on evenings that the flights were observed, as is discussed under "Method of Procedure".

Weather elements thought to be probable influences on the birds' behavior included: temperature, relative humidity, wind velocity, wind direction, barometric pressure, barometric pressure changes, and illumination. Two approaches were used for illumination: zenith light in foot-candles, and percentage of cloudiness. Barometric pressure changes considered were those between 6:00 A.M. and 6:00 P.M. In addition, time of year was included as another influence.

The method of linear multiple regression was used to estimate the influence of eight of the variables on the time of arrival of peak numbers of grackles and starlings. The ninth variable, wind direction,

was omitted because on preliminary study of the data it appeared to have very little effect on the timing of the peaks. Grackle and starling peaks for the southwest and north flights were selected for the multiple regression analysis, because they involved the greatest numbers of birds. Data for 1951 and 1952 were combined to give 21 observations on the grackles of the southwest flight, 21 for the grackles of the north flight, and 36 for the starlings of the southwest and north flights together. The majority of the observations in each case were for 1951.

The upper portion of Table 53 gives the results of all eight variables entered in the computations. Only the per cent of cloudiness has a regression coefficient that gives a significant t-test, but several other variables have moderate t-values. In the second part of the table are the results of the computations in which only the four variables with the highest t-values in the first test are used. Here time of year shows up as significant at the 5 per cent level, and both per cent of cloudiness and wind velocity are significant at 1 per cent. The multiple correlation coefficient, R, decreases only from 0.886 to 0.881 as a result of deleting four variables, evidence that they affected the birds' responses very little. When the change in barometric pressure is deleted and the coefficients recomputed, the remaining variables give tests of significance in the same order as before, and R decreases very little. The last step, in which the time of year is omitted, causes R to drop considerably more than in any prior test. Apparently that variable should be left in the list of consequential factors.

Thus, as far as the grackles of the southwest flight were concerned,

Table 53. Regression of flight peak time, in minutes to sunset, on weather factors and time of year for grackles from the southwest.

	Variables (21 observations)	Standard partial regression coefficients	t	R
X_1	Time of year	- .3382	1.30	0.886
X_2	Zenith light in foot-candles	- .0202	0.11	
X_3	Per cent cloudiness	.5278	3.00*	
X_4	Temperature in degrees Fahrenheit	- .0489	0.25	
X_5	Relative humidity	.0491	0.19	
X_6	Wind velocity in feet per minute	.5052	2.11	
X_7	Barometric pressure in inches	- .1371	0.59	
X_8	Change in barometric pressure from 6:00 A.M. to 6:00 P.M.	.2406	1.14	

$\hat{Y} = 316.3024 - 0.1139X_1 - 0.0013X_2 + 0.1574X_3 - 0.0826X_4 + 0.0357X_5 + 0.0273X_6 - 10.7521X_7 + 47.3973X_8$

Omitting X_2, X_4, X_5, and X_7

X_1	Time of year	- .3281	2.74*	0.881
X_3	Per cent cloudiness	.4821	3.87**	
X_6	Wind velocity	.5616	4.06**	
X_8	Change in barometric pressure	.2336	1.75	

$\hat{Y} = 8.2937 - 0.1105X_1 + 0.1438X_3 + 0.0304X_6 + 0.0562X_8$

Omitting X_2, X_4, X_5, X_7, and X_8

X_1	Time of year	- .3412	2.70*	0.856
X_3	Per cent cloudiness	.4990	3.80**	
X_6	Wind velocity	.4520	3.46**	

$\hat{Y} = 10.1687 - 0.1149X_1 + 0.1488X_3 + 0.0245X_6$

Omitting X_1, X_2, X_4, X_5, X_7, and X_8

X_3	Per cent cloudiness	.5434	3.59**	0.786
X_6	Wind velocity	.4388	2.90**	

* Significant at P = .05
** Significant at P = .01

the time of arrival of their peak numbers was affected primarily by wind velocity, cloudiness, and season. The appropriate regression equation is the third in Table 53. It indicates that the time of flight peaks for grackles from the southwest, in terms of minutes to sunset, decreased with the advancing season, increased with cloudiness, and increased with higher wind velocities.

A similar procedure of testing is outlined in Table 54 for grackles of the north flight. Because of experience with regression equations for the southwest flight, only five variables are entered in the computations: time of year, zenith light, cloudiness, wind velocity, and changes in barometric pressure. As the table indicates, zenith light gives a very significant t-test, and wind velocity tests significant. Time of year and changes in barometric pressure have very low t-values and R is 0.816.

Results of the second portion of the testing (Table 54), with time of year and change in barometric pressure omitted, show almost the same multiple correlation coefficient, R, obtained when the two factors were included in the computations. Zenith light tests significant at 1 per cent, as before, and wind velocity tests significant at 1 per cent rather than at 5.

When zenith light only is excluded from the computations (Table 54), R drops from 0.816 to 0.651. None of the standard partial regression coefficients now test significant, though the t-value for cloudiness is not far from the 5 per cent level of probability. Next, with both zenith light and barometric pressure change omitted, R drops but little,

Table 54. Regression of flight peak time, in minutes to sunset, on weather factors and time of year for grackles from the north.

Variables (21 observations)	Standard partial regression coefficients	t	R
X_1 Time of year	.0079	0.04	0.816
X_2 Zenith light	.5175	3.30**	
X_3 Per cent cloudiness	.2965	1.74	
X_6 Wind velocity	.3865	2.23*	
X_8 Change in barometric pressure	- .0569	0.29	
$\hat{Y} = 5.7081 + 0.0027X_1 + 0.0121X_2 + 0.0705X_3 + 0.0208X_6 - 6.3267X_8$			
Omitting X_1 and X_8			
X_2 Zenith light	.5268	3.63**	0.815
X_3 Per cent cloudiness	.2939	2.02	
X_6 Wind velocity	.4099	2.90**	
$\hat{Y} = 3.8034 + 0.0123X_2 + 0.0699X_3 + 0.0220X_6$			
Omitting X_2			
X_1 Time of year	- .0025	0.01	0.651
X_3 Per cent cloudiness	.4283	2.03	
X_6 Wind velocity	.3749	1.70	
X_8 Change in barometric pressure	- .1553	0.63	
$\hat{Y} = 17.7491 - 0.0009X_1 + 0.1018X_3 + 0.0201X_6 - 17.2756X_8$			
Omitting X_2 and X_8			
X_1 Time of year	- .0862	0.42	0.640
X_3 Per cent cloudiness	.4516	2.22*	
X_6 Wind velocity	.4434	2.36*	
$\hat{Y} = 13.9896 - 0.0295X_1 + 0.1073X_3 + 0.0238X_6$			
Omitting X_1, X_2, and X_8			
X_3 Per cent cloudiness	.4178	2.28*	0.635
X_6 Wind velocity	.4390	2.40*	

* Significant at P = .05

** Significant at P = .01

but cloudiness and wind velocity test significant at 5 per cent. When time of year is next dropped, R changes only slightly.

Everything considered, the second portion of Table 54 gives the regression statistics for the factors of greatest influence on the birds' time of arrival at the roost. Zenith light and wind velocity both test significant at the 1 per cent level, and per cent of cloudiness has a probability of about 6 per cent. The corresponding regression equation shows that the minutes to sunset, for peak numbers of grackles, increased with the amount of zenith light present, with per cent of cloudiness, and with wind velocity, for all regression coefficients have a positive sign.

In summary for the grackles, the birds of the southwest flight showed more of a seasonal response in time of arrival of their peak numbers than did the grackles of the north flight. Zenith light was of little consequence to the southwest flight, but was of real significance to the birds from the north. Per cent of cloudiness and wind velocity were consequential to both grackle flights.

Data from the southwest flight and north flight were combined to give a total of 36 observations for the starlings. Because some of the weather variables proved to be of negligible significance to the grackles, the assumption was made that they probably were equally unimportant to the starlings. Consequently only five variables were tabulated and tested by the method of multiple regression, the same five as used for grackles of the north flight. The results are shown in Table 55.

In Table 55, as in Tables 53 and 54, the successive blocks show the statistics obtained by deleting certain variables, and the second block shows the variables which apparently were of most consequence to the

Table 55. Regression of flight peak time, in minutes to sunset, on weather factors and time of year for starlings from the southwest and north.

	Variables (36 observations)	Standard partial regression coefficients	t	R
X_1	Time of year	- .2580	2.15*	0.785
X_2	Zenith light	.4874	3.92**	
X_3	Per cent cloudiness	.4185	3.54**	
X_6	Wind velocity	.1742	1.34	
X_8	Change in barometric pressure	.1563	1.24	

$\hat{Y} = 3.3478 - 0.0944X_1 + 0.0114X_2 + 0.1128X_3 + 0.0104X_6 + 24.3184X_8$

Omitting X_6 and X_8

X_1	Time of year	- .2162	1.86	0.765
X_2	Zenith light	.4559	3.86**	
X_3	Per cent cloudiness	.4595	3.97**	

$\hat{Y} = 11.4836 - 0.0791X_1 + 0.0107X_2 + 0.1238X_3$

Omitting X_2

X_1	Time of year	- .3496	2.45*	0.648
X_3	Per cent cloudiness	.5212	3.73**	
X_6	Wind velocity	.0267	0.18	
X_8	Change in barometric pressure	.1809	1.18	

$\hat{Y} = 14.2587 - 0.1279X_1 + 0.1405X_3 + 0.0016X_6 + 28.1454X_8$

Omitting X_2 and X_8

X_1	Time of year	- .3034	2.20*	0.628
X_3	Per cent cloudiness	.5427	3.90**	
X_6	Wind velocity	- .0432	0.31	

$\hat{Y} = 21.4103 - 0.110X_1 + 0.1463X_3 - 0.0026X_6$

Omitting X_1, X_2, and X_8

X_3	Per cent cloudiness	.5559	3.78**	0.550
X_6	Wind velocity	- .0655	0.45	

* Significant at P = .05

** Significant at P = .01

starlings. By comparing the first block with the second, it can be seen that deleting wind velocity and change in barometric pressure causes R to decrease only from 0.785 to 0.765. The first three variables predict the minutes to sunset almost as well as all five variables.

Although time of year does not test significant in the second portion of Table 55, its t-value is not far from the 5 per cent level, and when it is omitted from the computations in the last section of the table, it causes a considerable decrease in R, from 0.628 to 0.550.

The second regression equation in Table 55 indicates that the minutes to sunset decreased with the advancing season, and increased with zenith light and with per cent of cloudiness.

Therefore, time of year was an influencing factor for grackles of the southwest flight and for starlings. All birds tested responded to cloudiness. Grackles of the north flight and starlings were influenced by zenith light, but the southwest grackles did not show any clear reaction to it. Grackles of both flights responded to wind velocity, but starlings gave scarce heed to it in determining when most of them came to the roost.

A limited cloud cover, especially when the clouds were near zenith, caused higher readings on the light meter than did a clear sky. Only when the clouds were fairly extensive and thick did the light readings decrease when the per cent of cloudiness increased. Consequently the regression coefficients for zenith light turned out to have a positive value in each of the computations rather than a negative one as had at first been anticipated. Apparently zenith light was more of a measure of cloud formations than of over-all light conditions caused by the

angular altitude of the sun.

Nice (1935) found that in early October the largest flocks of grackles and starlings at Columbus, Ohio, approached the roost when zenith light ranged from 40 to 114 foot-candles, but that the height of the flight usually occurred between 52 and 65 foot-candles. Early October data for Ames, though limited to four observations for grackles and three for starlings, disclosed considerably higher light values for the peaks of the flights than found at Columbus. The grackle peaks occurred between 220 and 640 foot-candles, and the starling peaks between 365 and 640 foot-candles.

In view of the higher meter readings obtained with some clouds present than with a clear sky at Ames, these observations must not be interpreted as the result of general light conditions provided by a setting sun. When the percentage of cloudiness was about 10 per cent or less at Ames, there was little variation in the time of arrival of peak populations, but zenith light varied greatly because of the few clouds that were present.

Effects of thunderstorms. According to Jones (1897), grackles at Oberlin, Ohio, left their feeding grounds early in order to fly to the roost before a thunderstorm struck, provided the storm arrived after 4:00 P.M. Of the various thunderstorms that hit the Ames area during the several years of the investigation, only a few came between 4:00 P.M. and the usual flight time. Two such storms struck when the writer happened to be in the field to make observations, but on neither occasion did the birds respond as did those at Oberlin.

The first storm in question occurred on August 25, 1951. At 6:00

P.M., before any bird from the southwest flight had arrived at the roost area, the sky was at least 95 per cent cloudy, and a thunderstorm was in progress well to the south. Another storm to the southwest was rapidly approaching northeast Ames. It struck at 6:15 P.M., and with it came, in one huge flock, an estimated 6,000 birds that had gathered in the trees on Elm Avenue, Hazel Avenue, and other nearby streets. Most of the birds were grackles, but many starlings were among them. These birds rushed to the trees on Northwestern Avenue, Seventh Street, and vicinity. During the interval from 6:20 P.M. to 6:30 P.M., while the storm was in progress, about 700 other birds arrived and settled in the same trees. The storm, which was mostly wind and had only a small amount of rain, was practically over at 6:30 P.M.

That the birds which had rushed in with the storm, but not ahead of it, were only those already present locally, was shown by the flight counts after the storm had passed. In successive 10-minute intervals, beginning with 6:30 P.M., the estimates were as follows: 200, 680, 14,700, 2,240, and 10. Approximately three times as many birds arrived after the storm as during it. The birds apparently did not leave their feeding grounds early in order to reach the roost in advance of the storm.

By way of comparison, just two days prior to the storm, with a sky only 50 to 60 per cent cloudy, the flight had begun at 6:10 P.M. This was the same time that the 6,000 birds dashed in on August 25. The flight reached its peak at 6:50 P.M. and ended about 7:15 P.M., exactly as on the day of the storm except for the first rush of birds.

On August 8, 1952, a storm's effect on the east flight was observed.

The storm apparently was chiefly in its developmental stages as it passed eastward over the roost area. Although at 6:00 P.M. it caused only a mild sprinkle for about five minutes in Ames, lightning and thunder indicated considerably greater activity after it had passed farther east. During the 10-minute interval that began at 6:00 P.M., 30 grackles and 40 starlings came toward the roost area while it sprinkled. The next 10-minute interval, however, brought an influx of 6,100 grackles, 150 starlings, and 10 cowbirds to the roost area. To all appearances the storm had stimulated the nearby birds to come to Ames the moment it struck them. It had not caused birds farther away to leave their feeding grounds earlier to hasten to the roost, for a fairly normal flight followed the first rush of birds. Nearly 7,500 grackles, about 1,650 starlings, and 1,700 cowbirds arrived between 6:30 and 7:20 P.M.

On at least 10 evenings precipitation in the form of sprinkles or mist, unrelated to convection storms, fell just before or during the passage of a flight. On no occasion did the light rains have any apparent effect, but, as is indicated in another section, the cloudiness of the sky helped to determine the timing of the flight.

Directions of wind and flight populations

Jones (1897) found that the numbers of birds to reach the Oberlin roost from a given direction, with one exception, were reduced when they had to face strong winds. The exceptional flight which did not respond in this manner, he concluded, was too well organized to be affected. Jones did not define what he meant by strong winds.

For evidence of the effect of head winds on flight populations at

Ames, the assumption was made that any given flight was largely, if not entirely, composed of the same group of birds, at least after seasonal increments had stopped. Unless weather conditions prevented some birds from coming to Ames, therefore, the numbers of birds observed on any two successive evenings should be roughly the same. When contrasting wind directions or velocities did prevent some birds from following the usual flight line, or caused other birds to join it, the data on two consecutive days should show the results.

Apparently no one flight was observed on enough consecutive evenings to get conclusive evidence of the effect of head winds on the populations. Wind measurements, which showed sharp contrasts in direction and were reasonably strong, were never obtained for the same flight on successive days. To add to the difficulty, the observer was never able to be sure that some birds did not slip by, uncounted, when he was occupied estimating another group. Data pertinent to the problem which were obtained are given in Table 56.

Table 56 lists as couplets the data for consecutive days on which some contrasts in wind direction were observed. In two cases the couplets involved alternate days rather than consecutive. The wind direction, and velocities in feet per minute, are those determined for the peaks of the grackle flights for the evenings in question. Population estimates are given for grackles, starlings, and cowbirds. All data are for 1951.

Data for birds of the southwest flight on July 10 and 11 (Table 56), are exactly the opposite of expectations on the basis of the observations by Jones (1897). Though the wind was in a westerly direction on July 10,

Table 56. Direction of wind and flight populations in 1951.

Flight	Dates	Numbers of birds			Wind	
		Grackles	Starlings	Cowbirds	Velocity in feet per min.	Direction
Southwest	July 10	2,017	518	81	473	W
	11	5,386	1,240	150	440	NE
	Aug. 17	7,949	1,395	999	102	N
	18	11,480	2,445	315	22	SE
	21	16,076	2,823	1,206	128	NW
	22	11,829	4,181	376	37	E x NE
	22	11,829	4,181	376	37	E x NE
	23	17,136	3,390	162	345	SE
North	July 19	2,075	1,650	190	263	E x SE
	20	2,169	1,680	382	610	S
	20	2,169	1,680	382	610	S
	21	1,720	1,329	51	531	N
	22	1,687	1,514	126	137	N x NE
	23	1,719	1,844	128	48	E x SE
South	July 12	812	382	100	440	NE
	14	784	230	229	440	S
	Aug. 1	1,247	1,070	151	448	SE
	3	1,317	1,292	589	264	N
East	Aug. 6	4,558	650	7	295	NW
	7	7,629	1,743	96	264	S

and was directly opposite the direction of flight on July 11, the birds were considerably more numerous on the second evening. The two dates were early in the season, and apparently seasonal increments occurred in spite of a head wind. Both tail wind and head wind were of comparable velocities. For August 17 and 18 the grackles and starlings acted as expected, yet on neither day could the wind be classified as strong. Numbers were lower against the near-head wind on August 17, and were higher when the wind came at right angles to the line of flight on the next day. Cowbirds gave the opposite response. On August 21 the grackles and cowbirds were more abundant with the wind at right angles to their line of flight, and fewer in number on August 22 when facing the wind. Starlings showed the opposite trend. Again the wind on both days was far from strong. The last of the couplets presented for the southwest flight, the August 22 and 23 period, showed grackles to be down in numbers when facing the wind on the first day, and up in population with the wind at right angles the next. Starlings and cowbirds behaved oppositely. Some contrast in wind velocity existed, but the head wind on the 22nd was very light.

Observations for the north flight (Table 56) gave equally indefinite results. With the wind approximately at right angles to the birds on July 19, and a stronger wind opposing them on the 20th, the grackle and starling populations varied little on the two days. Cowbirds were more abundant against a stronger wind. In contrast, all three species of birds were more abundant against a head wind on July 20 than with a tail wind on July 21. The difference in wind velocities was not great, though the head was a little stronger. The next two days, July 22 and 23, saw

approximately the same grackle and cowbird population both evenings. The first evening the birds had a tail wind to aid them, while on the second the wind was approximately at right angles to their line of flight. Starlings were more abundant with the wind at right angles.

Two couplets of data were obtained for the south flight (Table 56), both on alternate days rather than consecutive. With a near-head wind on July 12, and a tail wind of similar proportions on July 14, bronzed grackles showed approximately the same population both evenings. Starlings were more abundant when they had to face the wind, while cowbirds were over twice as numerous with a tail wind. For the August 1 and 3 period, grackles arrived in roughly equal numbers both with the wind and against it, though starlings and cowbirds came in larger numbers against the wind. The tail wind in this case was stronger than the head wind.

One couplet for the east flight is presented in Table 56. On August 6, with a near head wind, the populations of all three species of birds were lower than on the following day when the wind came at right angles to the line of flight. On both days the wind velocities were very similar.

Table 57 gives a summary of the effects of wind direction on the population trends observed at Ames. Grackle populations increased twice against head winds, but decreased four times and remained the same on three occasions. More frequently than not the starlings and cowbirds increased in population when they faced the wind. All three species of birds showed decreases in numbers with tail winds, and only once did the cowbirds show an increase with such winds. Tail winds of the magnitudes measured apparently tended to reduce the numbers of birds that came to

the Ames roost. The effects of stronger winds on flight populations were not observed.

Table 57. A summary of the relation between direction of wind and population trends in the flights.

Species of bird	Type of wind	Frequencies of population trends		
		Up	Down	Same
Grackle	Head	2	4	3
	Tail	0	2	3
	Right angles	4	0	2
Starling	Head	6	2	1
	Tail	0	5	0
	Right angles	3	2	1
Cowbird	Head	6	3	0
	Tail	1	3	1
	Right angles	2	3	1

Effect of trains

Both the south and southwest flights crossed railroad tracks near which the writer made his observations. Because one to three trains ran almost every evening during the time that the flights were on, and frequently some trains did considerable switching, there was ample opportunity to watch the birds' responses to them.

The reactions of the birds to the trains, most of which had Diesel engines, were definite and quite dramatic. Moving trains with their accompanying roar apparently were frightening stimuli, and the birds ordinarily refused to cross them. An arriving flock invariably milled

around considerably when a train was passing. Some turned back to perch in nearby trees, and others continued to mill around until the train passed. When a long drawn-out flock of birds was crossing the tracks of an approaching train, the line of birds bent away from it, even as much as two to three or more blocks. Usually the train caught up with the veering line of birds and caused it to split. Those birds on the roost side of the train continued their flight, but those on the other side milled around wildly, or flew to perch in some trees. After the train had passed, the flight continued and the birds followed the normal flight line. Several times the birds were observed to shy aside when a standing train merely sounded its horn or whistle.

A standing train was no deterrent to the birds, although they never crossed a steaming or noisy engine. On several evenings groups of two or three birds hesitatingly crossed a moving train but they did so near the rear. Larger flocks were never observed to do this.

The reaction of the birds to trains was in sharp contrast to the absence of any visible reaction to the few airplanes that flew over the birds during the investigation. On several occasions the airplanes flew relatively low, but not a bird was seen to veer away, speed up its flight, or give any other manifestation of disturbance.

Dipping

While on their way to the roost at night, some of the birds at times displayed a striking behaviorism called "dipping" in the investigator's notes. For no apparent reason they suddenly lowered their altitude of flight, flew for a distance at the new level, then resumed their original

altitude. Sometimes only a few birds were involved, and sometimes many. On occasion an entire flock of hundreds of birds performed, but more frequently only a portion of a group made the maneuver. Waves of dipping, which often progressed forward in the flock, were also seen. Often the dips were rather weakly developed, and the performers lowered their level of flight only three or four feet. At other times the birds dropped 20 feet or more, and even to within three or four feet of the surface of the earth. The number of dips seen per evening varied greatly, for sometimes only one or two were observed, sometimes many, and just as often none at all. Dipping was not the behavior of a given group of birds, for it was observed on all four flights and during all the years of the investigation.

The phenomenon of dipping was probably related to the organization of the flocks. It was never seen earlier than July 8, when the flights were definitely increasing in numbers, and both frequency and intensity of performance tended to increase with the advancing season. Most dips were given during the peaks of the flights, although many were performed earlier in the evening. Neither the earliest arriving birds, nor the last ones, were ever observed to dip. Dipping was always observed over open areas, never over trees.

Dipping was primarily a grackle phenomenon, though a number of dips were seen that involved a mixture of grackles and starlings. On three occasions small groups of starlings made the maneuver by themselves, and a few robins were seen twice to do so. Only once, when two birds out of a flock of 17 performed, was the behaviorism noted among cowbirds. Dipping was never seen in flocks composed of both grackles and cowbirds.

No special stimulus was ever detected which caused the birds to dip. On several occasions a distant gun shot was immediately followed by a dip, but at other times similar noises failed to produce the response. On several evenings the writer clapped his hands when the flight was passing directly over him, but the only result was to cause the stream of birds to veer to one side, not to dip.

Since the majority of the dips were performed during the peaks of the flights, when the writer was more than busy getting population estimates of the birds, most of the notes concerning them had to be recorded well after the performances were over. Consequently data obtained were too sketchy to be used in determining any definite correlations with weather phenomena. Nevertheless, it was observed that dipping occurred on evenings with all degrees of cloudiness, with wind from 14 different directions and with a range from almost calm to an estimated 20 to 25 miles per hour. It took place at temperatures which varied at least from 82.5 to 51.0 degrees Fahrenheit, at relative humidities from 89.5 to 27.5 per cent, and on days when the barometer was either rising or falling.

A preliminary account of the dipping behavior was given by Bliese and Hendrickson (1952).

Relatively few observations of the flights were made early in the morning when the birds left the roost, but on two mornings in October, 1952, dipping was noted among the grackles. The behaviorism, therefore, was not confined to evening flights to the roost.

Table 58 gives a chronological summary of such notations as were secured for the phenomenon. Unless stated specifically to the contrary, grackles are meant throughout.

Table 58. A chronological record of dipping as seen at Ames.

Date	Flight	Number of dips	Notes
1950			
Aug. 12	North	Many	Dips came within 10 to 20 feet of the ground.
15	East	1	A flock of 200 birds suddenly dipped to three feet above the ground, and flew thus for several hundred feet.
Sept. 6	North	Many	Dips came within a few feet of the ground, and the birds then flew about 100 feet or more before rising. One dip followed the squeal of a child, but others had no apparent cause.
7	North	Several	Dips came within a few feet of the ground. One dip occurred as a wave which worked forward in the flock.
20	South-west	Many	Dips were over an open field, just before reaching the railroad tracks. All were 10 feet or less.
24	South-west	4	Dips involved drops of only 10 feet or less.
25	North	Many	Some dips were over 20th street, and others were over a field.
26	North	3	
1951			
July 10	South-west	2	Each time a flock of about 20 birds gave a weak dip as it crossed R.R. tracks.
18	North	3	Only five to ten birds left the main flock each time. The birds dropped only three or four feet in altitude.
22	North	2	A group of seven grackles dipped slightly at 7:10 P.M. Later at 7:20 P.M. two grackles did the same.
25	North	Several	Each time two or three birds left the main flocks to dip five or six feet. These happened during the time the peak of the flight was on.

Table 58. (Continued)

Date	Flight	Number of dips	Notes
July cont'd			
26	North	2	Only a few birds were involved in each slight dip. Dips occurred about 7:00 P.M. and 7:20 P.M. when streams of birds arrived.
31	South-west	Several	Only five to 10 birds dipped each time. Dips occurred when the steady flight was on.
Aug. 1	South	1	A well developed dip was given by a string of grackles.
2	North	2	Some grackles gave rather slight dip, at 6:50 P.M. At 7:10 P.M. a small mixed group of grackles and starlings gave a weak dip.
7	East	Several	The streams of birds dipped. One dip brought the birds within inches of the top of growing corn. Once a lone starling dipped.
17	South-west	Several	Several weak dips were given during the peak of the flight. At 7:25 P.M. a group of robins dipped when a door slammed.
18	South-west	Several	Several mild dips were seen. Several robins gave a dip at one time.
21	South-west	5	Dips were well developed.
22	South-west	1	One tremendous dip was given just south of the 6th Street overpass. The dip involved a string of grackles and starlings at least 300 feet long. Children whooping suddenly had no effect.
Sept. 6	North	4	All dips occurred when the steady part of the flight was on. One dip progressed forward, like a wave, for at least 300 feet in the flock.
6	North	1	The dip formed over 13th Street about 6:20, five seconds after a shot was heard.
24	North	Many	

Table 58. (Continued)

Date	Flight	Number of dips	Notes
Oct. 3	South-west	1	Two grackles from a large flock, dropped 10 to 12 feet in altitude. The other birds did not follow.
11	South-west	Several	All dips were weakly developed.
15	South	1	The dip was seen about 5:30, when many birds were coming.
24	South-west	Several	Dips were well developed.
1952 July 8	South-west	2	Both dips were weak ones. They occurred when the birds came in a continuous stream.
9	North	1	Two cowbirds, in a flock of 17, gave a dip about 7:00 P.M.
10	East	2	One grackle, of a group of two, dipped. Two grackles, of a flock of 25, dipped.
Aug. 5	North	1	One flock of 30 starlings gave a well-developed dip about 6:50 P.M., when the grackle flight was at its peak.
6	South	2	A well developed dip by a portion of the stream of grackles was seen about 6:50 P.M. About 25 grackles dipped at 7:00 P.M. during the peak of the flight.
8	East	1	Five starlings, in a group by themselves, gave a dip about 6:50 P.M., when the peak of the starling flight was on.
Sept. 1	South-west	1	Two grackles, from a stream of the birds, gave a dip.
4	North	2	At 6:00 P.M. two grackles, out of the many present, gave a strong dip of 15 to 20 feet. A flock of 70 grackles performed a dip that almost touched the ground.

Table 58. (Continued)

Date	Flight	Number of dips	Notes
Oct. 3	South	1	One slight dip by a flock of 80 grackles was seen.
4	South-west	3	At 5:20 P.M. about 300 grackles dipped about 10 feet just before reaching some electric wires. The dip was a very quick one. The birds were part of the streams of birds. About 5:30 P.M. some 200 grackles, part of a stream of birds, dipped weakly. About 300 grackles gave a dip of approximately 15 feet. Again, they were a part of the stream of birds.
7	North	3	A flock of 2,000 grackles gave two dips about 5:20 P.M. The dips, which lowered the level of flight 20 to 30 feet, progressed forward and included the entire flock. At 5:30 P.M. the leading 100 birds, from a flock of 430, dipped from 10 to 15 feet. The remainder of the flock did not follow suit.
8	East	2	About 50 grackles, part of a stream of birds, gave a dip of 20 feet or so at 5:30 P.M. The dip was a minor wave which progressed forward. Two grackles, from a flock of 14, gave a dip of 20 to 25 feet at 4:20 P.M.

SUGGESTIONS FOR THE CONTROL OF CITY ROOSTS

Although the present investigation was not intended to lead directly to methods of control of roosts, some suggestions for mitigating the roosting problem came as by-products of the research. Several of the proposals resulted from a study of the birds' use of the roost, and one from observations of the flights.

Since the birds used the closely grouped trees whenever possible, selective cutting to break up the groups is recommended as a local measure to prevent the formation of a roost site. The drastic removal of all trees on the premises to get rid of the birds, such as occurred at one place in Nevada, Iowa, seems unnecessary.

Isolated hard maples were seldom used as roost places in Ames. Therefore, from the viewpoint of roost prevention, the planting of hard maples in rows is to be questioned. Alternate hard maples and American elms or other species is suggested.

Trees planted as close as 25 or 30 feet apart, as is true in many places in Ames, results in compact growth that apparently attracts the birds. A distance of at least 50 feet is suggested as more desirable. This would give each tree superior opportunity to develop better shape or form, would permit better growth of lawn because of less dense shade, and would still adequately shade the individual residences.

Because the birds showed a tendency to roost in trees with denser foliage, pruning could conceivably give local relief from the birds, at least in some species of trees; but since pruning is apt to be followed

by the growth of many new branchlets which restore the cover and result in abundant perches (Kalmbach, 1945), it could be expected to be of value as a control measure for only a season or two. Pruning of sufficient extent to discourage the birds in the dense hard maples, on the other hand, would probably do irreparable harm to the trees.

At best the preceding suggestions are local expedients, but blackbird roosting becomes a community problem by late June or early July when the birds begin to increase seriously in numbers. From then on local efforts, when they produce any results at all, result only in a change in roost sites within the city. Control measures of any consequence must be attempted on a community basis.

Since the birds at Ames were observed to form definite flight lines by the last of June, it would seem quite feasible at that time for some interested organization to meet the in-coming flights with shotguns at the edge of the city. The flight lines could be located in a very few evenings, and the gunners stationed accordingly. The efforts would probably have to be repeated for a number of evenings in succession. As judged from observations at the catalpa grove near the Maney Memorial Park in Ames, probably few birds would actually have to be killed, and many of the shells used at any one site could probably be blanks. Repeated attacks during the season might or might not be necessary. All efforts should be made in cooperation with the local conservation officer, and with the local police if necessary.

SUMMARY

1. The summer and fall roosting of bronzed grackles and their avian associates at Ames, Iowa, was studied from August, 1949, to November, 1952. Associated birds included the starlings, cowbirds, and robins. English sparrows, purple martins, and a few giant red-wings were also present on occasion.

2. The purposes of the study were as follows: (a) to learn whether or not certain readily measureable features of the roosting sites were correlated with the extent to which they were used by the birds; (b) to learn whether or not readily measureable weather phenomena were correlated with the behavior of the birds; (c) to observe the responses of the birds to interference by people; (d) to add to our knowledge of the natural history of the bronzed grackles and their associates.

3. During the years of the investigation noticeable roosting in Ames began in the latter half of June and extended into the first part of November.

4. Two study areas were kept under observation. The one located in the residential areas south of the college was used extensively as a roost only in 1949. Northeast Ames, the other area, was used extensively by the birds during all four years of the investigation.

5. In 1950 the birds roosted on 120 city blocks, in 1951 on 64, and in 1952 on at least 40 blocks. The decrease in number of blocks was related to a decrease in bird populations.

6. Whether the trees were used lightly, moderately, or heavily by the birds, a considerably larger number and percentage of street trees than back yard trees served as roost places.

7. On a numerical basis roosting in Ames from 1950 to 1952 was primarily noted in the American elms, black maples, and Norway maples. With the exception of 1952 when only 18 Norway maples were used as roost places, 20 or more of these species were used by the birds each year, but cottonwoods approached this number with a count of 14 trees in 1951, and silver maples were next with nine roost trees in 1950.

8. In 1950, 51.9 per cent of the American elms and hard maples and 16.6 per cent of all other species combined were used as roost trees. In 1951 the corresponding data were 38.5 per cent and 15.7 per cent, and in 1952 they were 30.4 per cent and 4.5 per cent, respectively. The downhill trend was correlated with a decreasing bird population.

9. There were more American elms in the city than any other species of trees, and more were used as roost places all three years. On a percentage basis the hard maples, with one exception, were considerably in the lead. The exception occurred in 1950 when American elms and Norway maples used as roost places showed 46.8 and 44.4 per cent of use, respectively. The two species of hard maples reversed their relative positions twice during the study.

10. Other species of trees for which at least two trees were used as roost places included: green ash, basswood, box-elder, cottonwood, hackberry, silver maple, catalpa, and Chinese elm. All but the green ashes and basswoods showed a percentage of use of 25 per cent or higher in at least one of the three years, 1950 to 1952.

11. The nuclei for roost sites in the city formed at least as early as the first part of June. All observed roost places at that time were in black maples. Roost sites began to grow considerably during the latter half of the month, and other deciduous trees also were used then.

12. Two seasonal changes in the use of species of trees were noted in June: (a) the birds began to leave the spring roosts in coniferous groves in the country and to come to the deciduous trees in the city; and (b) they began to use American elms and other species of trees in addition to black maples.

13. In general, as the bird population increased during the summer, there was an increase in the percentage of roost places for all tree species used by the birds. There was no evidence of any changing use of species of trees as the season advanced. Such changes as were noted were explainable on the basis of shifts to new roost sites, or to reduction of bird populations due to migration.

14. With only four exceptions no trees less than seven inches DBH were used as roost places. The exceptions were two six-inch Norway maples, one four-inch downy hawthorn, and one six-inch hackberry, all near larger trees that were in extensive use by the birds.

15. Percentages of trees used as roost places tended to be in proportion to their sizes. This was generally true whether the trees were examined for degree of use (light, moderate, or heavy), or merely for use regardless of degree, but the smallest trees ordinarily were used only lightly, or not at all.

16. Black maples subjected to light roosting had a pattern of use of their own, for these trees showed a general decrease in percentage of

use with increase in size.

17. The birds used larger percentages of the smaller hard maples than of similar-sized trees in other species.

18. When the mean DBH's of the trees were compared according to the degree of use received (light, moderate, or heavy), it was found that black maples showed increasing degree of use with increasing mean DBH. Norway maples, and all trees other than the American elms and hard maples, showed the same tendency to a lesser degree, but American elms had no special pattern.

19. The differences between the mean DBH's of trees of any one species not used as roost places and those used as roost places were tested for significance by the t-test. With only the exception of the 1951 black mpales, which tested significant at the 5 per cent level, all trees for all three years, 1950 to 1952, tested significant at the 1 per cent level. Within a species of tree, at least, the birds definitely tended to ignore the smaller trees and to use the larger ones.

20. The birds roosted in hard maples of smaller average DBH than of the American elms. The same sizes in different species of trees did not have the same ability to attract the birds, as judged from the means.

21. Back yard trees, when enough were used as roost places so that a trend could be shown, were found to have the same general increase in percentage of use with an increase in size as the street trees. This was especially true in 1951 for American elms and all species other than the American elms and hard maples. In 1952 too few trees in back yards were

used for any trends to be visible, and in both 1951 and 1952 too few hard maples were used to display any tendencies.

22. When back yard trees were considered from the viewpoint of mean DBH, it was found, as with street trees, that the mean DBH of trees not used as roost were considerably smaller than the mean DBH of trees that did serve as roost places. When the differences between the means were subjected to t-tests, the means for American elms in 1952 tested non-significant, but those for 1951 were significant at the 5 per cent level. All trees other than American elms and hard maples tested significant at the 1 per cent for both years. The t-tests were not made for the hard maples because too few were used as roost. There was no clear trend between degree of use and mean DBH for back yard trees.

23. The birds tended to select the more closely grouped trees as roost sites, for the average distance from roost trees to the nearest trees was less than the corresponding average from non-roost trees to the nearest trees. This relationship was found at various times during the season and also for the annual summaries for three successive years.

24. The birds' use of the more closely grouped trees was somewhat of a relative matter, for some mean distances for roost trees were actually greater than some mean distances for non-roost trees. Apparently the birds used the more closely planted trees at each roost site, when possible, but the closeness of the trees at one site was not always the same as at another.

25. On the average the back yard non-roost trees were farther apart from each other than were street non-roost trees, but roost trees in back yards were grouped about as closely as were street roost trees.

Apparently there were not very many close groupings of roost-size trees in back yards, and the relative absence of such may have been a primary reason for the small percentage of back yard trees used by the birds.

26. The differences between the means of the annual summaries for grouping of trees were compared statistically by t-tests. For street trees the 1950 mean differences showed significance at the 5 per cent level and those for 1951 and 1952 were non-significant. For back yard trees the 1951 data showed no significance, but the 1952 mean differences tested significant at 5 per cent. Since the manner of handling the data caused a considerable tendency to equalize the means for roost trees and non-roost trees, the fact that even two mean differences tested significant lends considerable support to the contention that the birds showed a decided tendency to select closely grouped trees for roost sites.

27. The birds used American elms selectively for density of cover, and gave progressively greater degree of use to those elms that were denser. Cover density was determined by expressing the noon-day light getting through the crowns as a percentage of the light in the open.

28. The hard maples provided much denser cover than other trees, and the birds used a greater percentage of them as roost places than American elms; but once within the range of cover provided by the hard maples, the variations in densities of individual trees had little effect in determining which hard maple was used lightly, moderately, or heavily.

29. The few trees other than American elms and hard maples that were measured for cover density, had relatively high percentages of light getting through their crowns. The generally more open crowns of these trees may have been one reason why more of them did not serve as roost places.

30. Trees used by the birds in late October had less cover than trees used earlier, but the birds, forced to use such cover as remained, followed their tendency to use more intensively those trees with the heavier cover.

31. When the percentages of light were determined within the tree crowns at the level where the birds roosted, only the American elms showed a definite tendency of lower percentages with increasing degrees of roosting use. The hard maples showed irregular trends with no particular interpretation, and averaged considerably lower than American elms. One Chinese elm, used lightly by the birds, showed a percentage of light comparable to that found for lightly used American elms.

32. Efforts at roost control in Ames were limited to activities by individual citizens. The primary methods used in attempts to disperse the birds or drive them elsewhere were the following: sudden loud noises, beams of light, use of guns, and tree removal. Most efforts were of a desultory nature and were not persistent enough to produce serious results. Noise-making and beams of light seemed to thin the population at several sites, and may have been partly responsible for causing the birds to move from one or two places. Firecrackers tossed into the roost trees cleared an extensive roost site, and the use of a shotgun for only three nights caused an estimated 20,000 birds to leave a grove of catalpa trees. None of the methods tried were of much value after the birds had settled for the night.

33. Four main flights of birds came to the northeast Ames roost area each evening. Three of the flights were quite regular in the location of their flight lines, and one was very erratic. All flights shifted their

flight lines somewhat in correlation with shifts in roost sites as the season advanced.

34. Flight lines were never less than one city block wide, and two of the flight lines often had a breadth of about seven city blocks. On none of the flights were the birds evenly distributed along the entire breadth of the flight line, but concentrations occurred at fairly definite places.

35. Populations of flocks too large to be counted were estimated by five's, 10's, or 100's. Mechanical tally counters were used to keep track of the numbers. No satisfactory method was discovered to check the accuracy of estimating huge flocks, though total numbers obtained on successive days seemed reasonably similar when weather conditions were the same. By counting as well as estimating it was learned that small flocks of 23 to 46 birds were estimated with 94.5 per cent accuracy. The tendency was to underestimate.

36. Flights to the northeast Ames roost area began with small numbers in late June, increased until maximum populations were reached in August or September, then decreased with the advent of the fall migration.

37. The several flights into Ames differed markedly from each other in total numbers of birds present. Since any given flight also varied considerably in population from one year to the next, the flights changed their relative order of importance in contributing to the roosting problem. Total populations decreased progressively from 1950 to 1952.

38. The several species of roosting birds were roughly present in the following percentages in 1951: bronzed grackles, 74; starlings, 22;

cowbirds, 3; and robins, 1. The percentages varied between flights and also from day to day.

39. Early in the roosting season the grackles arrived either singly or in small groups. Larger flocks were formed then, and by mid-July some of the flights had over one-half their population in flocks of 50 or more birds. By August the percentages of birds that arrived in the largest flocks were usually in the 80's or even high 90's. Every flight throughout the season had some birds which arrived singly or in small flocks.

40. Starlings demonstrated a growth of flocks similar to the grackles, but with one difference. On evenings when starlings and grackles were present in about equal numbers in the hundreds, rather than thousands, a greater percentage of the starlings were in larger flocks than was true of grackles. When each of the two species numbered in the thousands, approximately the same percentages were present in the larger flocks.

41. Although cowbird flocks also increased with the season, they ordinarily were not present in large enough numbers to form flocks over 50 birds in size.

42. Grackles, starlings, and cowbirds flew together in various proportions. Although robins sometimes flew with the other three species, they never were numerous enough to be in the majority.

43. Grackles usually flew at tree-top height, cowbirds 10 to 20 feet higher, and starlings flew two or more times higher than the grackles. Mixed flocks flew at the altitude typical of the more abundant species, though no mixed flocks were ever seen at the high starling altitude.

44. Strong gusty winds caused lower flight than usual.

45. Times of flight beginnings for grackles, starlings, and cowbirds tended to occur closer to sunset time as the season advanced. The 1951 data for the combined southwest and north flights resulted in over-all mean times for flight beginnings, in minutes before sunset, as follows: grackles, 61.8 minutes; starlings, 50.0 minutes; and cowbirds, 49.5 minutes.

46. Times of flight peaks for the three species of birds tended to parallel the times of flight beginnings. The 1951 means, in minutes before sunset, were as follows: grackles, 15.1; starlings, 18.5; cowbirds, 31.4.

47. For flight endings, the 1951 averages disclosed that grackle flights ended 13 minutes after sunset, and starlings 2.6 minutes after sunset. Cowbirds were all at the roost by 10.7 minutes before sunset.

48. As the season progressed the total duration of the flights of all three species decreased. Grackles accomplished this both by beginning to come to the roost closer to sunset and also by finishing closer to sunset. Starlings and cowbirds had little seasonal change in time of flight ending, but shortened their total flight period by coming to the roost nearer to sunset time later in the year.

49. Robins were the last birds to reach the roost each evening. Although a few robins arrived as early as the first grackles or starlings, the peaks of the robin flights occurred when only stragglers of the other birds were arriving.

50. The effect of weather elements and time of year upon the timing of grackle and starling peaks was tested by the method of linear multiple regression. Grackles of the southwest flight were affected primarily by wind velocity, cloudiness, and the season. Those from the north responded

chiefly to zenith light, cloudiness, and wind velocity. Starlings from both flights were influenced chiefly by season, zenith light, and cloudiness. Regression coefficients for season were negative, and those for the other factors were positive.

51. Moderate cloudiness caused the light meter to give higher readings than a clear sky. This caused the regression coefficient for zenith light to have a positive value rather than a negative one.

52. Thunderstorms that occurred near flight time caused the birds already gathered nearby to rush to the roost when the storms struck, but apparently had no effect on those birds some distance away. Light precipitation, such as sprinkles or mist, had no noticeable direct influence on the birds.

53. The effects of winds stronger than about 600 feet per minute on total flight population were not observed. Limited evidence indicated that moderate head winds, more frequently than not, were associated with increased populations of starlings and cowbirds. Grackle data of similar nature were indefinite. All three species of birds showed decreases in numbers with tail winds of 500 feet per minute velocity or less, although once cowbirds showed an increase.

54. Though they crossed standing trains freely some distance back of steaming, noisy engines, the birds did not cross trains that were moving. Long drawn-out flocks that were crossing the railroad tracks were frequently split by an approaching train.

55. The birds in flight frequently performed a maneuver which is called "dipping" in this thesis. It consisted of a sudden drop in altitude, flight at the new level for some distance, then a return to

the previous elevation. Sometimes one or two birds were involved, sometimes many. The phenomenon increased with the season, both in frequency and in intensity of performance, but was not seen every night. Dipping always occurred over open areas, never over trees. No stimulus was discovered which initiated the behaviorism. It was performed chiefly by grackles, but was also seen among the other species of birds.

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